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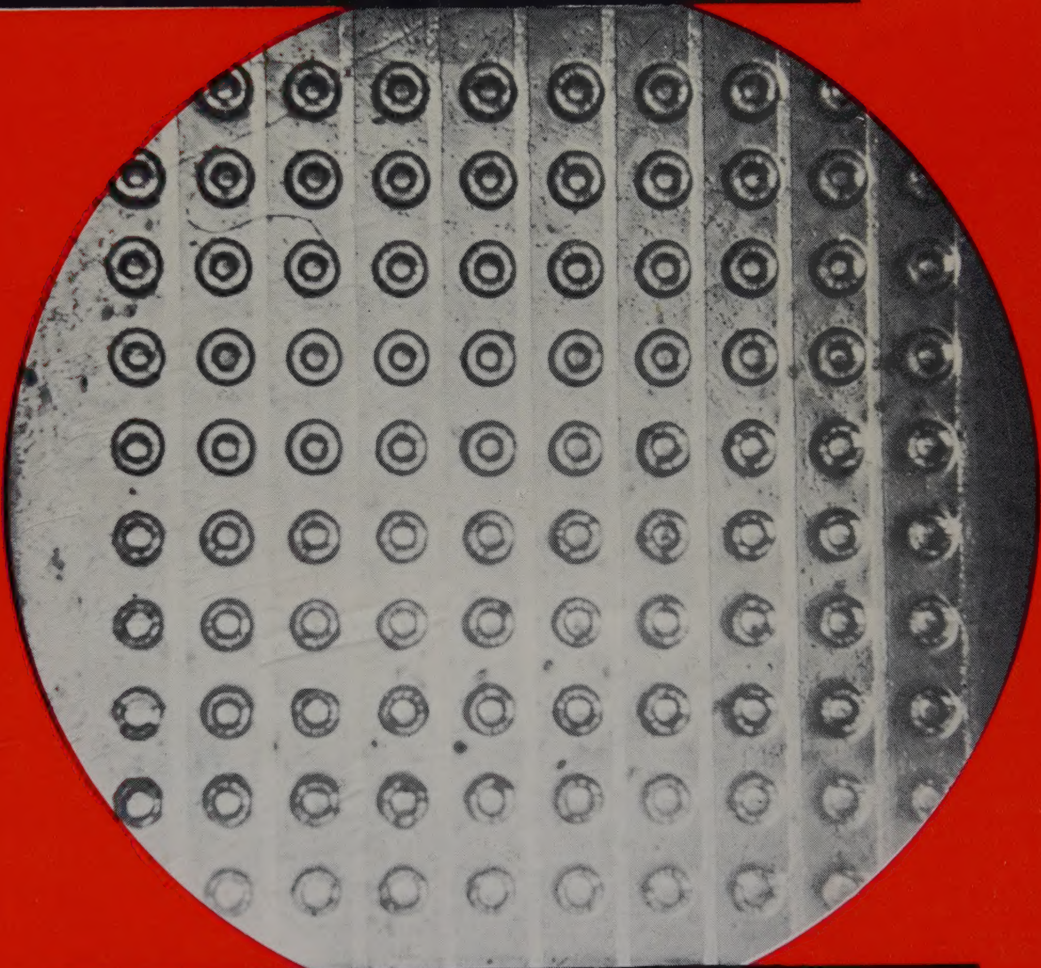

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January 1961 Vol. 4 No. 1

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Front Cover

The Diamond Ordnance Fuze Laboratories has designed and built 2 cameras to prepare microphotographs for the fabrication of semiconductor devices. The first use of microphotographs was in the fabrication of diode matrices. The device shown consists of an array of 100 diodes in 10 parallel rows. (See article "Microphotographs For Electronics" on page 37.)

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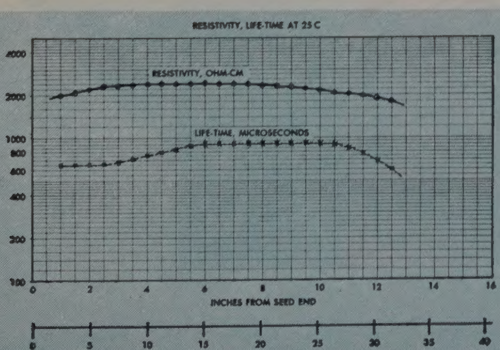

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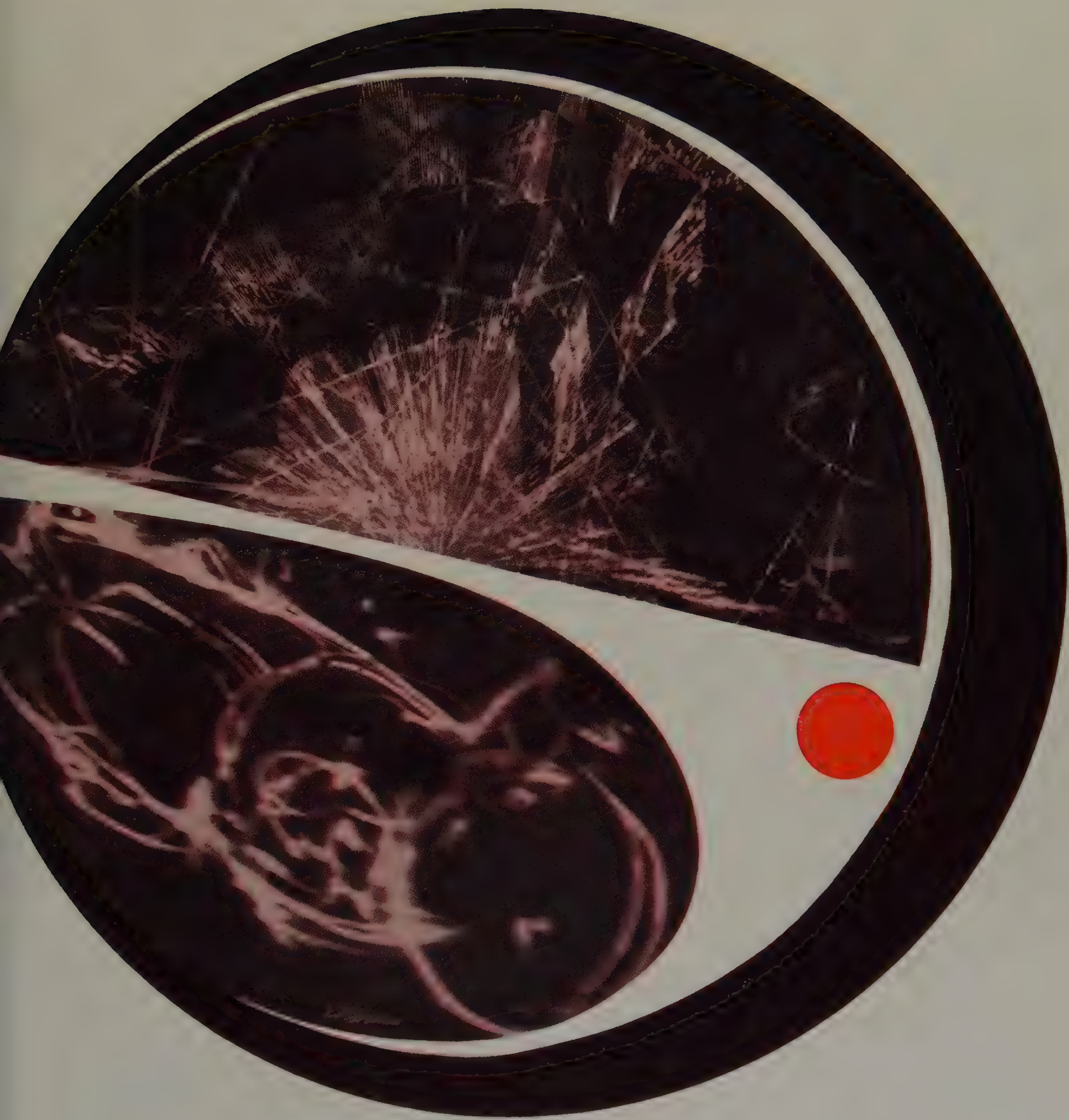

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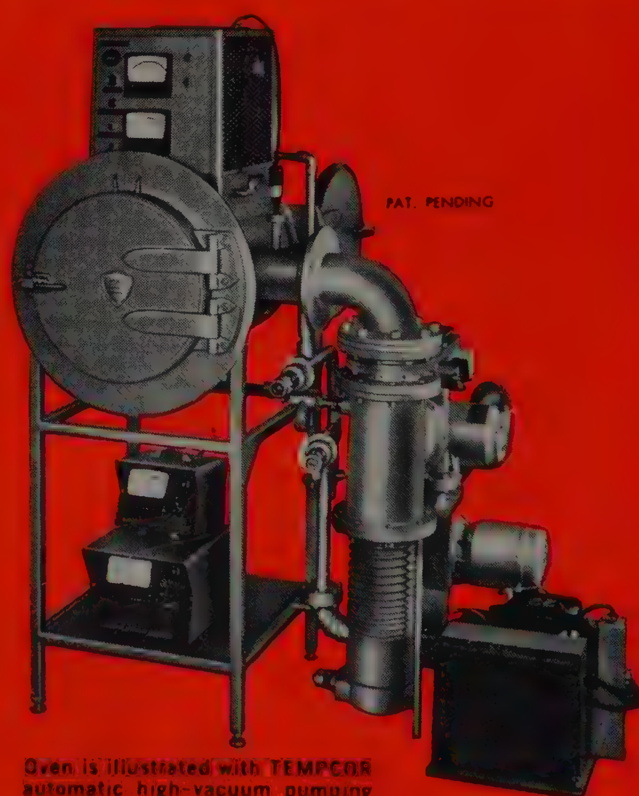

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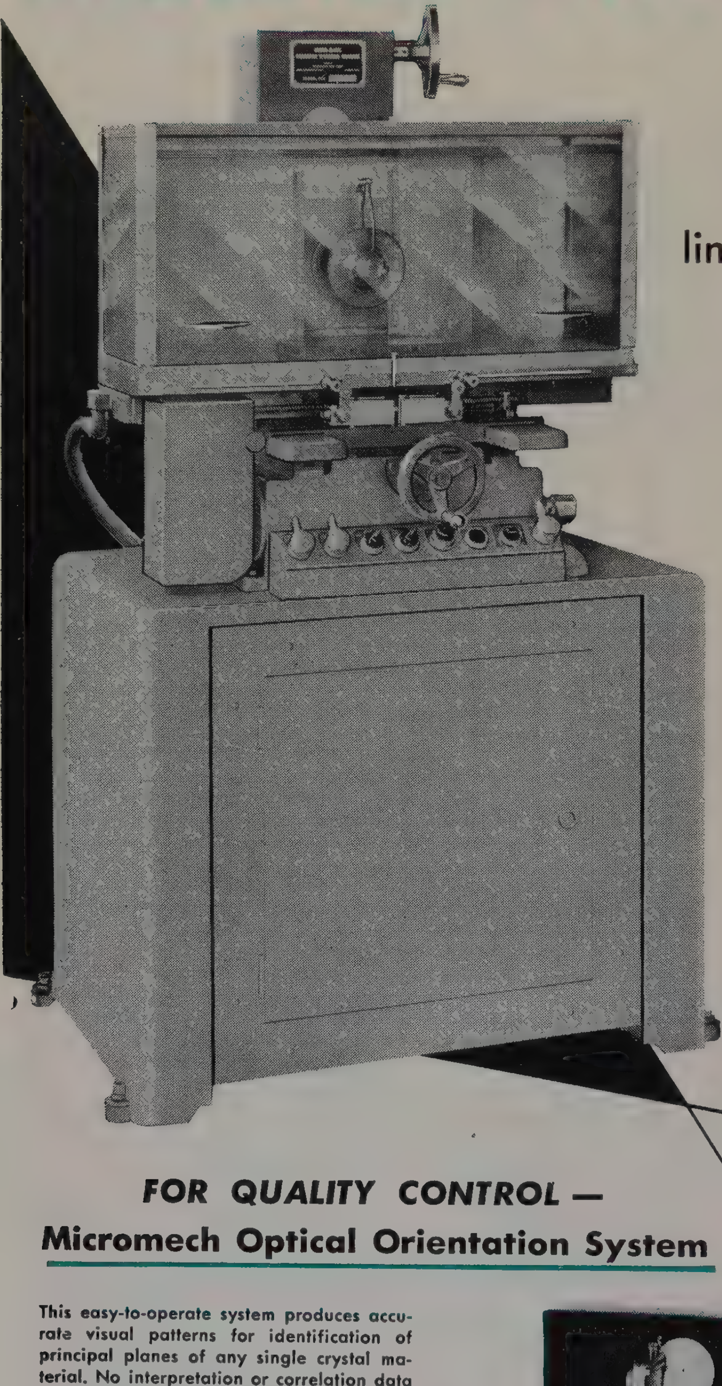

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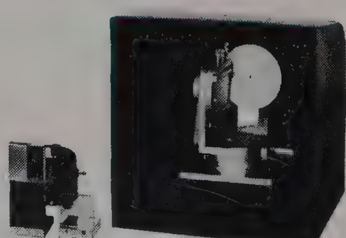

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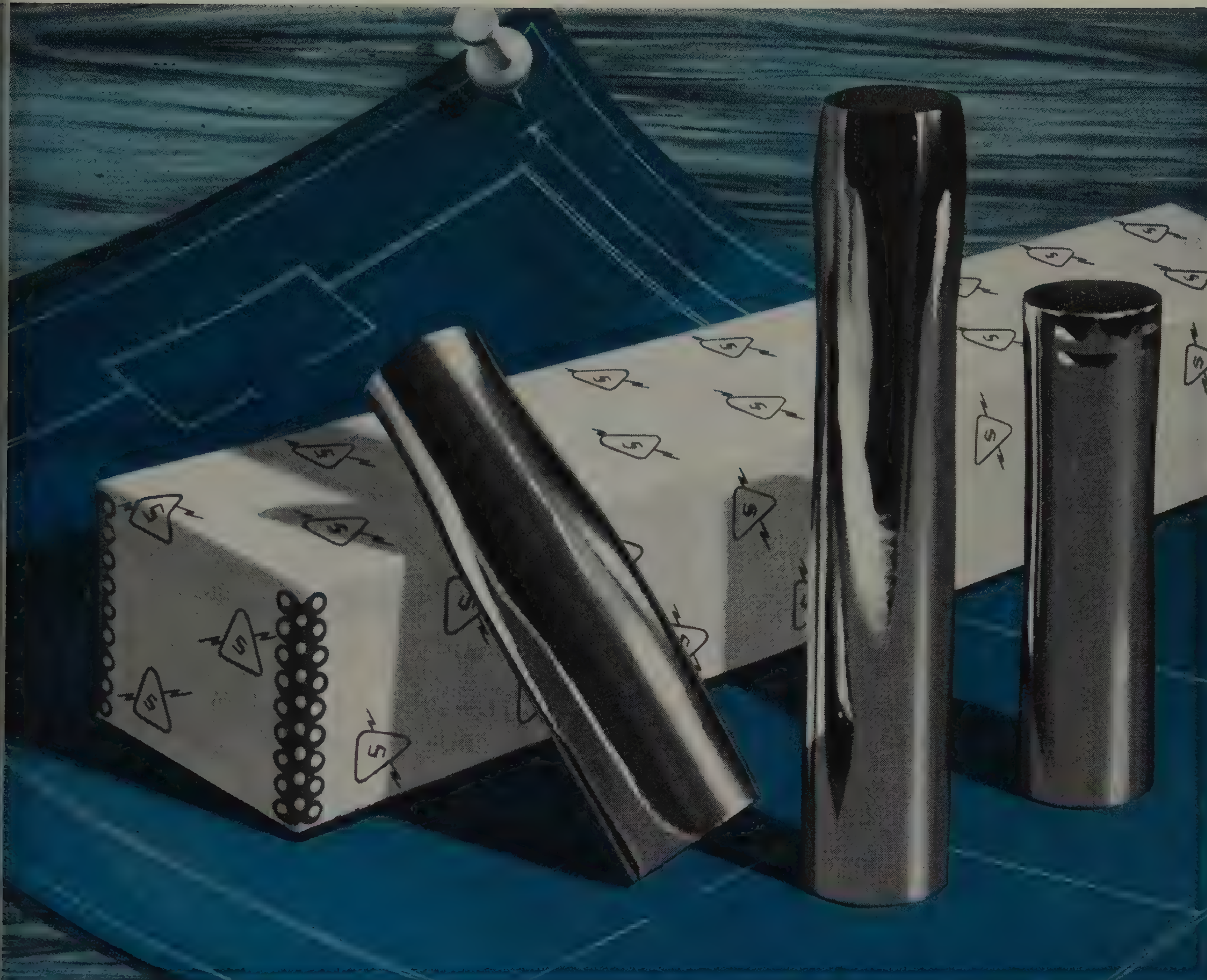

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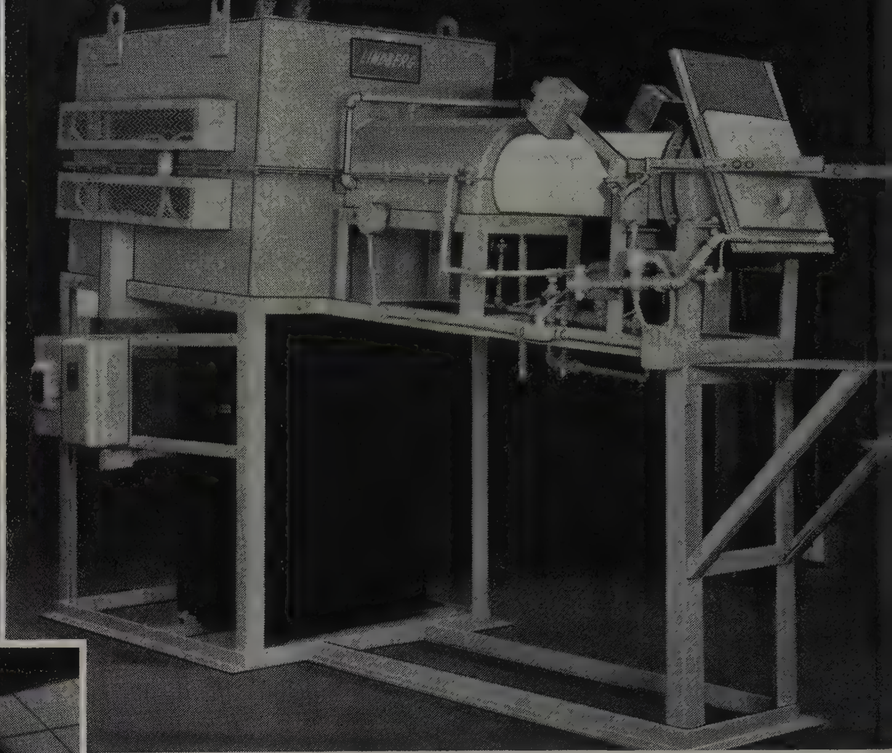
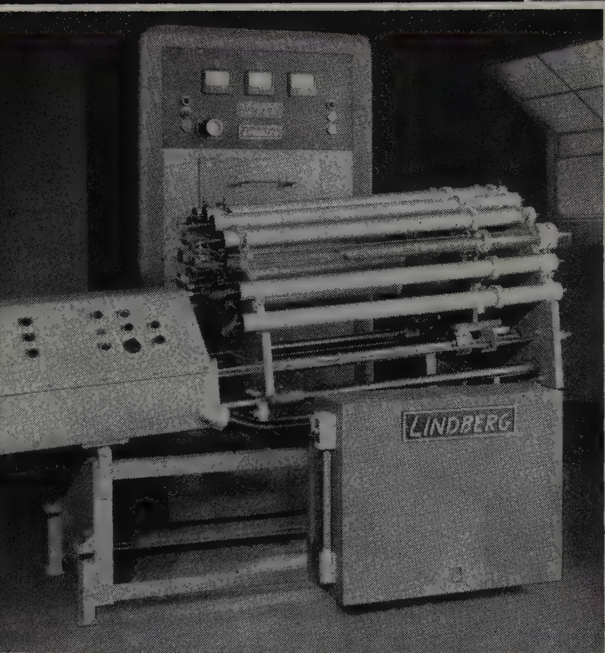


This Lindberg Hydrogen Atmosphere Furnace is designed for the reduction of germani oxides and other materials. Model illustrated is a hand pusher type but this furnace also available for continuous, automated operation.



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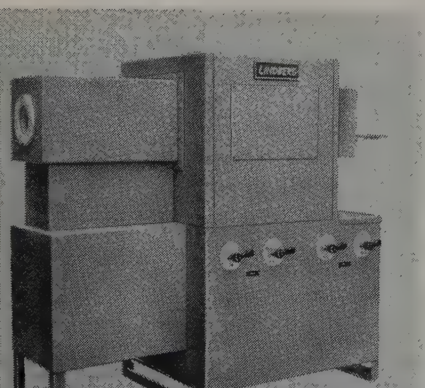
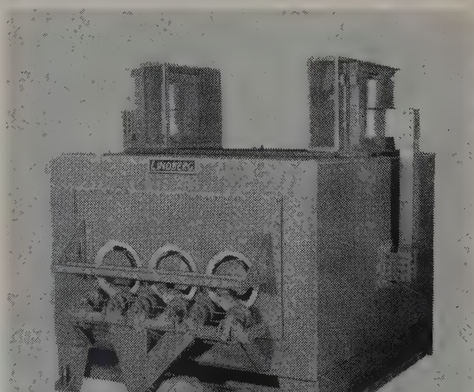
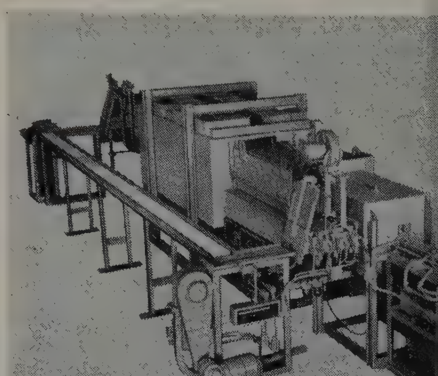


This is one of a line of Lindberg Solid and Gaseous Diffusion Furnaces especially designed for research, pilot plant study, and production of quality transistor and semi-conductor devices. They can be had in single and multiple zone models. Encapsulation furnaces also available.



Lindberg Three-Tube Electric Rotary Calciner for calcining ferrite powders. This model is equipped with Lindberg CORRTHERM heating elements. Lindberg Calciners can be supplied with either fused quartz or alloy tubes. When required, gas-fired models are also available.



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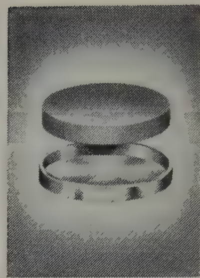
Western Electric is typical of the many successful diode and transistor producers who use Alpha gold alloy preforms as a high temperature solder. They employ *Goldcups* for attaching wafer to base tab or for making electrical contact between leads and studs.



Alpha Goldcup and molybdenum disc before fusion. Illustration 15 times actual size.

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Book

TITLE: Advances in Cryogenic Engineering

AUTHOR: K. D. Timmerhaus, Editor

PUBLISHER: Plenum Press

Advances in Cryogenic Engineering is the fifth volume of this series and is an excellent collection of papers presented at the Fifth National Cryogenic Engineering Conference held at the University of California in September of 1959. Cryogenics is the study of the behavior of various materials at very low temperatures close to absolute zero. With the development of missiles requiring liquid fuel propellants, cryogenic engineering has taken a remarkable forward step. This book presents the results, theories and work of many of the leading cryogenic specialists of today.

There are eleven basic headings or chapters each containing a collection of five or more papers. The first group of papers deals with applications and techniques. The paper by Blanks and Timmerhaus outlines various engineering problems and advances in cryogenics for space age engineering. This paper discusses some of the problems in the use and handling of liquid rocket propellants and refers the reader to other papers in the book for more detailed discussions. There are several very interesting papers dealing with the large-scale production and handling of liquid hydrogen (sec A-4 P.C. Vander-Arend).

The next two sections of the book entitled "Missile Technology" and "Insulation," deal in detail with the problems of handling and keeping liquid fuels. The problems of heat transfer and a discussion of recent developments in exchanger designs may be found in section E entitled "Heat Transfer." The liquefaction of gases and refrigeration techniques are covered in section G which also describes several infra-red cryogenic cooling systems.

The balance of the book covers a variety of topics such as Fluid Phenomena, Mechanical Properties, Processes and Data, and Design and Applications.

This fifth volume of *Advances in Cryogenic Engineering* is a very informative and well edited collection of papers. The technology described is new and of great importance in missile development. This excellent volume and its four predecessors will undoubtedly find their well deserved place in any comprehensive engineering library.

Reviews

TITLE: Semiconductors and Transistors
AUTHOR: Douglas M. Warschauer
PUBLISHER: McGraw-Hill

Semiconductors and Transistors is a well written textbook that introduces the transistor to the reader in a tutorial manner. The book can be roughly divided into two sections, the first dealing with semiconductor physics and the second with transistor design and operation.

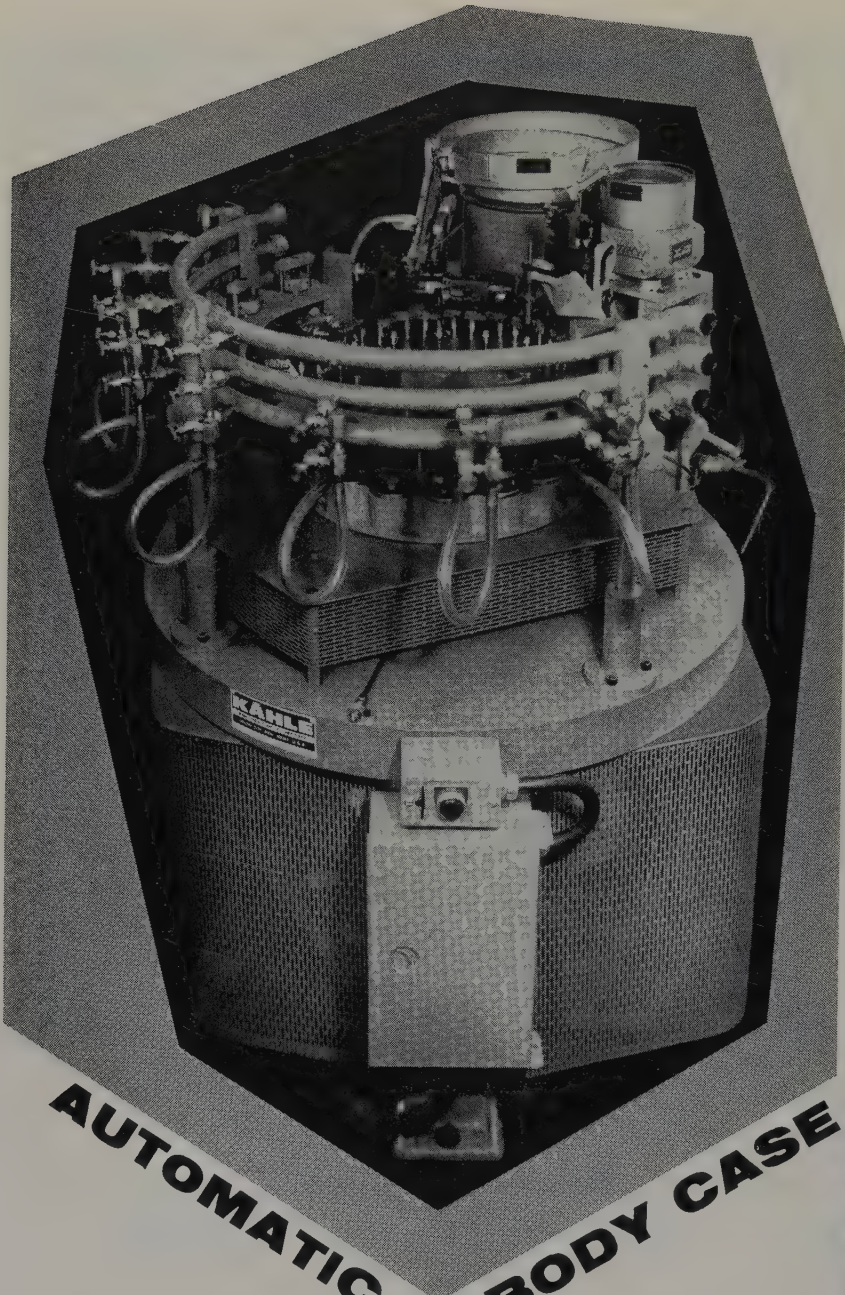
The first seven chapters comprise a complete study of metals, semiconductors and insulators in terms of field theory, crystal composition, energy levels and atomic structure. A great deal of material is presented in a highly understandable form. Only the parts of the field theory necessary to establish a point are used. Simple schematic representations of electron motion through solids clearly illustrate the phenomenon of current flow.

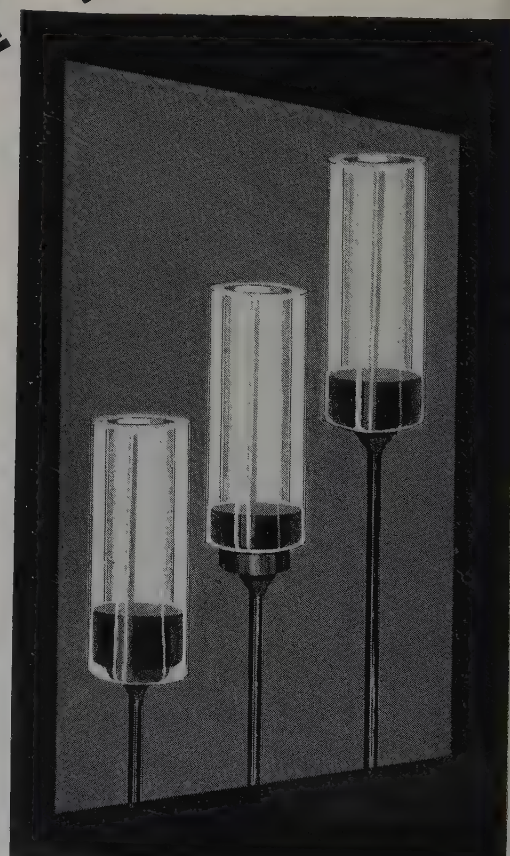
The balance of the book stresses the transistor as the logical outgrowth of the semiconductor study. Chapter 8 outlines the terms, quantities and method of measurement of semiconductor characteristics. The ninth chapter discusses the p-n junction as an introduction to the transistor.

Chapters 10, 11 and 12 cover the physical theory, actual construction and circuit operation of the transistor in good detail. The remaining chapters deal almost solely with transistor circuit theory. Here much material is covered in a very adequate manner for an understanding of transistor circuitry, however, actual design information is somewhat lacking (there is practically no information on biasing for temperature stability). Switches, oscillators and high frequency circuits are also discussed.

Semiconductors and Transistors is an excellent textbook for an undergraduate course in transistors, a use to which it will undoubtedly be put. It is also a good book to introduce transistors to the design engineer who may expect to pursue the study of actual circuit development further. The book is well written and highly understandable.

By Stephen E. Lipsky





Editorial . . .

The Effective Mass of Electrons in Semiconductors

The mass of a particle is defined by means of its acceleration under an applied force. For example, under an electric field E, a free electron experiences an acceleration $a = qE/m$, where $m = 9.1 \times 10^{-31}$ kg is the so-called rest mass. When the same electron is constrained in a crystal lattice, its mass is found to depend upon its energy state k. The effective mass is expressed in general with the differential relationship

$$m^* = \left(\frac{h}{2\pi}\right)^2 \bigg/ \frac{d^2W}{d\,k^2}$$

where W is the electron energy corresponding to its state. For a free electron one has $W = p^2/2m = h^2k^2/2m$ i.e. the W versus k curve is a parabola; correspondingly the above relation gives $m^* = m$. The energy band in a solid crystal possesses a W versus k curve which deviates from a parabola and in fact presents an inflection point near the middle of the band. Hence the effective mass of an electron is infinite near the middle of the band and is respectively positive and negative below and above said level. The electrons with negative effective mass are called holes and are considered to possess positive mass. In general, therefore, the effective mass is a function of energy state and also of direction within the crystal, since the W versus k relation is represented by a nonspherical solid in general.

Experimental information about the effective mass is obtainable through cyclotron resonance experiments, since, under an applied static magnetic field B, electrons and holes describe spiral orbits with angular velocity

$$W_e = \pm \frac{qB}{m^*}.$$

Resonant absorption of energy from an R-F field perpendicular to B occurs at $W = W_e$. The above experiments also provide a measurement of m^* in various directions. For example, for silicon at 4°K, near a minimum of the conduction band, it is found that $m^*/m = 0.19$ in the transversal (or x, y) direction, and $= 0.98$ in the longitudinal (or z) direction. For many applications an average value of the effective mass must be taken as for example

$$1/m_{av} = \frac{1}{3}\left(\frac{1}{m_l} + \frac{2}{m_t}\right)$$

where m_l and m_t are respectively the longitudinal and the transversal mass.

The concept of effective mass has an important bearing on many aspects of semiconductor theory, such as those connected with the Hall effect, with the magneto-resistance effect, with the electrical conductivity theory, with the infrared absorption, etc. As an example, spin resonance absorption of conduction electrons at frequency ω is obtained with a static magnetic field $B = \omega m^*/q$. In order that such effect may be extended to infrared frequencies with suitable values of B, it is necessary to make recourse to materials with as low a value of effective mass as possible. One such material is indium antimonide with $m^* \cong 0.014\,m$.

Season's Greetings

With this issue we embark upon our 4th year of publishing SEMICONDUCTOR PRODUCTS. We are proud to have been of service for the past three years to this fast-growing and exciting industry. At this time we would like to express our gratitude for your support and to extend our wishes for a Happy and Prosperous New Year.

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Temperature uniformity is tough to achieve. Yet, a Hevi-Duty user reports that his 22-inch-long, 2-inch I. D. furnace has only a ±1°C. temperature variance over 10 inches of furnace length at 1275°C.

Temperature uniformity — so important to producers of semi-conductor products — has been important to Hevi-Duty for years. Attention to this factor has paid off. It has made Hevi-Duty the respected furnace name in the semiconductor industry.

Whenever critical temperatures must be met, you'll find Hevi-Duty equipment. For years, the largest semiconductor manufacturers have used Hevi-Duty furnaces and ovens for zone refining, crystal growth, alloying, lead attachment, surface treatment and encapsulating.

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HEVI-DUTY

Electric and Fuel-Fired Industrial Furnaces and Ovens

B P C — A Division of Basic Products Corporation

Hevi-Duty Electric Company, Milwaukee 1, Wis.

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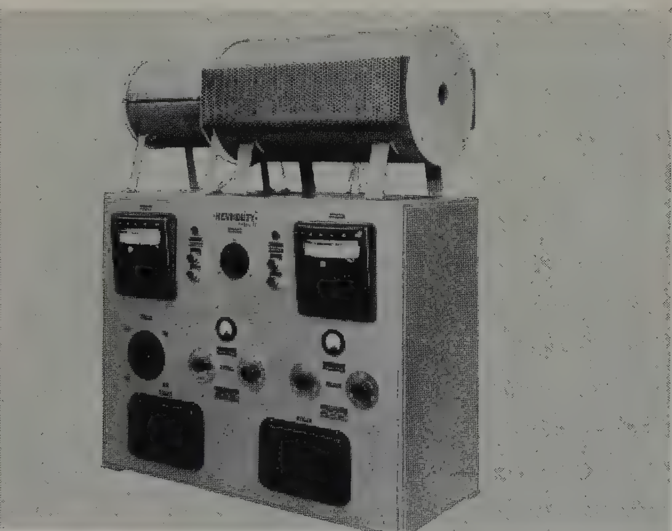
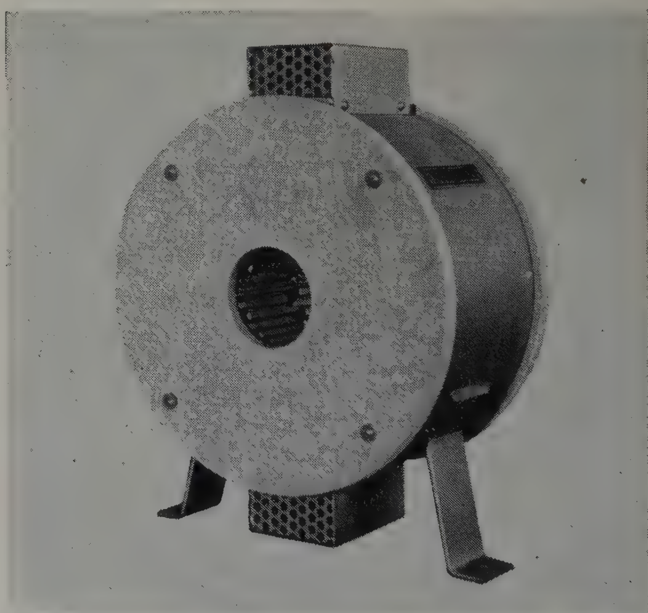
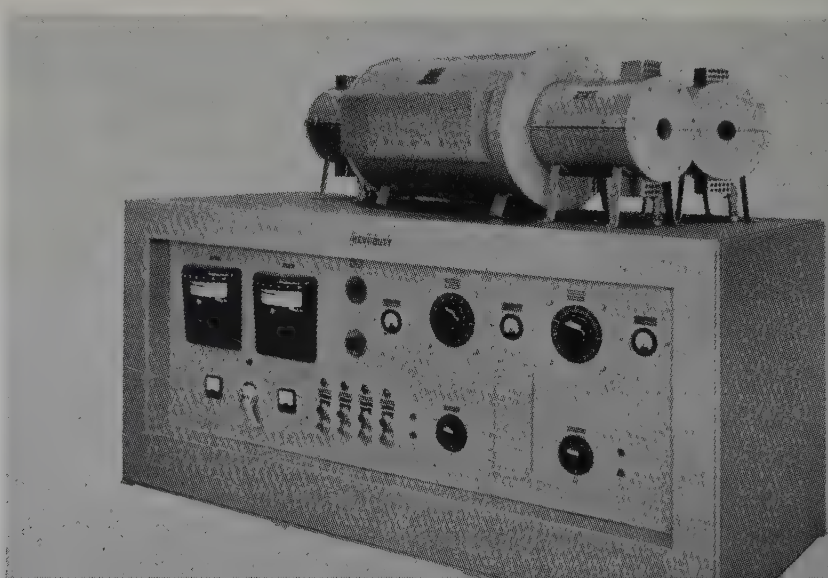


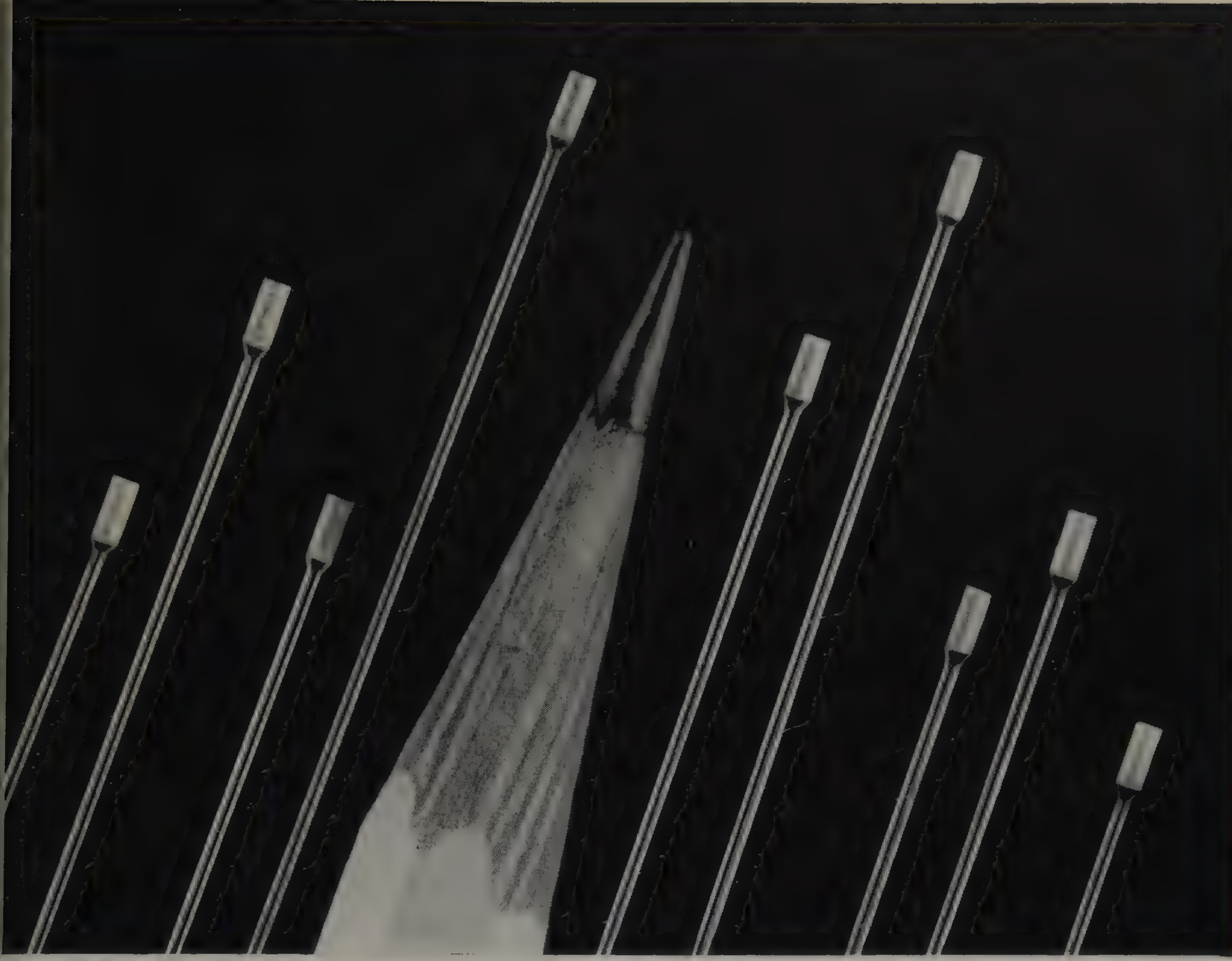
This special Hevi-Duty furnace assembly is designed for alloying transistors. An automatic saturable reactor temperature control system is built into the base. A preheat furnace operates at temperatures to 2200°F while the two-zone high-heat furnace operates at temperaturs to 2600°F.

Zone refining is accomplished in this special tube furnace with a 3-inch I. D., 4-inch-long heating chamber. The furnace operates at temperatures to 2200°F and can be easily adapted to move along a track for either crystal growth or zone refining.



These two furnaces are being used successfully for the diffusion of silicon wafers. Boats are preheated in the small furnace to the right and then placed in the three-zone high-heat furnace. The cabinet contains saturable reactor controls that automatically maintain correct temperatures in each furnace.





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steps up reliability... cuts shrinkage

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This is just one more advance in welded assemblies from Sylvania. And whether you need hand-welded, semiautomatic or fully automatic production techniques, Sylvania can do all to meet your requirements. At Sylvania, too, unique quality control is assured throughout.

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SYLVANIA

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Industry News . . .

CONFERENCE CALENDAR

The Following February 1961 Meetings Are Scheduled:

Jan 30-Feb 3	ASTM Committee Week meeting, Netherland Hilton Hotel, Cincinnati, Ohio. Sponsored by American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.
Feb 1-4	American Institute of Physics Annual Meeting, Hotel New Yorker, NYC.
Feb 1-3	2nd Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles. Sponsored by PGMIL LA Section. For Information: Dr. John Myers, Hoffman Electronics Corp., 3717 S. Grand Ave., Los Angeles.
Feb 15-17	International Solid-State Circuits Conference, University of Pa., and Sheraton Hotel, Philadelphia, Pa. Sponsored by PGCT, AIEE, Univ. of Penna. For Information: Jerome J. Suran, Bldg. 3, Rm. 115, General Electric Co., Syracuse, N. Y.
Feb 26-Mar 2	AIME Annual Meeting, Ambassador & Chase-Park Plaza Hotels, St. Louis, Mo. Sponsored by The Metallurgical Society of AIME, 29 W. 39th Street, New York 18, N. Y.
Feb 27-Mar 3	Conference on Analytical Chemistry & Applied Spectroscopy, Penn Sheraton Hotel, Pittsburgh, Pa.

RESEARCH AND DEVELOPMENT

A team approach to commercial research that closely unites many scientific disciplines is producing results at the new research facility of the Hoffman Electronics Corporation in Santa Barbara, Calif. Immediate and pressing problems are being solved on a day-by-day basis by the team of senior scientists. Silicon, for instance, tends to accumulate moisture on its surface which deteriorates devices made of this material. Techniques are beng sought to bond materials to the oxide coating of the silicon that do not inhibit the movement of "holes" and electrons within the device but which will prevent the absorption of moisture. The process is called passivation.

Technology is finding ways to increase the power-handling capacity of semiconductor diodes, but the attendant rise in heat generated in these devices thus far shortens their operating lives. A project underway at the Hoffman Science Center is keyed to the development of a technique that will remove a maximum amount of this heat from the semiconductor juncture. These are but two examples of the research projects in progress at the Center.

General Instrument Corporation recently announced receipt of a contract from the National Bureau of Standards to design and fabricate a low powered, propane-fueled thermoelectric generator system for evaluation as a power plant for the Navy's first unmanned ocean based automatic weather station, now beaming back vital weather information from 300 miles out in the middle of the Gulf of Mexico. Designed to supply enough power to run all the floating weather station's electrical and electronic equipment, the system will be capable of operating continuously for a year on 225 gallons of propane. It will include a fuel supply (propane in this case), a flameless burner (which oxidizes the gas, thereby eliminating burner fouling and clogging), the thermoelectric generator (with semiconductor thermopiles which convert the heat directly into electricity), and a nickel-cadmium battery (to store the constantly produced electricity and deliver peak amounts, 12 volts, 30 amperes hours, when needed).

An Infrared Guidance Sensor to control final orientation of American space probes during their flights to Venus and Mars is now being developed by Barnes Engineering Company of Stamford, Conn. This development is being sponsored by the Jet Propulsion Laboratory at the California Institute of Technology in Pasadena which is the prime contractor in developing the probe vehcle for use in the National Aeronautics and Space Administration's Mariner program. Terminal guidance by infrared has been selected because of its extreme compactness and simplicity, and because infrared equipment has the high precision inherent in optical instruments.

The infrared guidance sensor detects objects by means of the infrared radiation that is emitted by all materials at temperatures above absolute zero, and can distinguish these objects from their much colder space background. In the Mariner probes, the sensors must have extreme sensitivity since only small amounts of infrared radiation will be available from the two target planets. The infrared radiation from Venus will be coming from the top of its dense atmosphere, which is at a temperature of minus 54 F. The radiation from nearly airless Mars will be coming from its surface, which is at plus 45 F at the equator, and minus 90 F at the poles. Because of the low temperatures of the emitting surfaces, the infrared that will be available for navigation purposes will be at long wavelengths. Most detectors that are sensitive to these wavelengths require cooling by bulky liquid gas systems and are unsuitable for a compact space vehicle installation. Thermistor bolometer detectors are sensitive to these long wavelengths without the need for cooling, and are consequently the most practical for this application.

When the sensor is ready to take control at a distance of 100,000 miles from either planet, its first task will be to find the target. To do this, the sensor contains a pair of counter-rotating prisms that will scan the infrared detectors' small, sensitive field of view in a rotating rosette-shaped pattern, 70° in diameter. As the detector sweeps across the planet's horizon, it senses the sharp change in infrared radiation and develops electrical signals that are amplified and processed for use in control.

Diode Parametric Amplifiers

Principles and Experiments

Part 1

E. D. REED*

Though a comparative newcomer to the low-noise microwave field, the diode parametric amplifier has already become established as a practical and important building block of modern microwave systems. With noise performance spanning the range between that of low noise tubes and masers, this device appears to be the answer to a variety of preamplifier needs in the frequency band from 500 *mc* to well above 10,000 *mc*. In this article, the physical principles involved in the operation of the major types of diode parametric amplifiers are reviewed and a qualitative explanation given of the variable-capacitance effect in semiconductor diodes. The application of these principles and also of these diodes in typical experimental low noise amplifiers are also described. Finally, the noise performance of the diode parametric amplifier is compared with that of low noise vacuum tubes and masers and the more important considerations which enter into the choice of an appropriate low noise amplifier for particular applications are indicated.

DURING THE RECENT PAST we have witnessed exciting developments in the field of microwave low-noise amplification. The monopoly which the vacuum tube has enjoyed here for many years has been seriously challenged by competition from solid state devices. This, in spite of continuous and significant improvements in the noise performance of tubes. There have been three solid state entries: the maser, the variable-capacitance amplifier, and the variable inductance (or ferro-magnetic) amplifier. The first two, the maser and the variable capacitance amplifier, have emerged successfully from the early exploratory phase and have already demonstrated their practicality and great future potential in a number of experimental systems. They are well on their way to becoming established as indispensable building blocks of modern microwave systems.

In this race for lower and lower noise, we find the maser far in the lead since the noise associated with its basic amplifying mechanism is negligibly small. So small, in fact, that for the first time in history, receiver noise has ceased to be á basic limitation on sensitivity over much of the microwave spectrum. In many applications, however, we cannot benefit from this ultimate in noise performance and are therefore unwilling to pay the cost of refrigeration and the magnetic field needed for masers. For these applications, the variable-capacitance amplifier (or parametric amplifier as it is often called) offers the advantage of simplicity. Its noise performance lies somewhere between that of vacuum tubes and masers, yet, in contrast to masers, neither refrigeration nor a magnetic field are required. If, nevertheless, we are willing to introduce a moderate amount of refrigeration, that is, refrigeration to liquid nitrogen temperature, further—and rather significant—improvements in noise performance can be obtained.

The principles of parametric amplification have long been appreciated. Recognition of these principles has, in fact, been traced back as far as Lord Raleigh. The rediscovery of these principles, however, and application to low-noise microwave amplification is only about three years old. Historically, the maser came first. It was followed by the variable-inductance amplifier which grew out of attempts to apply the paramagnetic maser principle to ferromagnetics. This work, in turn, sparked the variable-capacitance amplifier.

The first variable-capacitance amplifier for operation at microwave frequencies was built by M. E. Hines at Bell Telephone Laboratories about three years ago. Since then the activity in this field has grown to such an extent that today practically every laboratory, here and abroad, with an interest in low-noise amplification is participating in this work. A survey which appeared in Electronic News in November, 1958, listed some three dozen laboratories in the United States engaged in various phases of parametric amplifier work.

By far the major part of the parametric amplifier effort to date has been centered around the use of the variable capacitance effect in semiconductor diodes. Parametric microwave amplification using ferrites as variable inductance elements has also been demonstrated but significantly low noise figures have not as yet been reported. Work is also in progress on electron beam parametric amplifiers. The outstanding

*Bell Telephone Laboratories, Incorporated, Murray Hill, New Jersey

example here is the Quadrupole Amplifier by R. Adler of the Zenith Radio Corporation. In his tube, quadrupole fields act parametrically upon the fast cyclotron wave of an electron beam to produce amplification. While Adler's original tube has yielded excellent low-noise performance at around 400 *mc*, A. Ashkin of Bell Laboratories has more recently been successful in extending the application of Adler's ideas to low-noise amplifiers operating at around 4000 *mc*.

In this article we shall deal primarily with the variable-capacitance amplifier since it has clearly emerged as the most attractive and practical one of various parametric amplifiers mentioned above. We will review the principles involved in the operation of the three major types of variable-capacitance amplifiers which have yielded significant experimental results, namely the negative-resistance amplifier, the up-conversion amplifier and a third type which is really a hybrid of the other two in that it uses both negative resistance-gain and up-conversion gain. We shall present a qualitative treatment of the variable capacitance effect in semiconductor diodes and describe the application of these principles and also of these diodes in a number of experimental low-noise amplifiers. Finally, we will compare the noise performance of the three principle microwave low-noise amplifiers, namely parametric amplifiers, vacuum tubes, and masers, and consider some of the criteria which enter into the choice of a suitable low-noise device for particular applications.

The Negative-Resistance Amplifier
Physical Principles

The simplest introduction to the physical principles involved in negative-resistance type of parametric amplification is based on the—by now well known—low frequency analogue of the mechanically pumped capacitor. Let one of the capacitor plates, say the upper plate, in the simple resonant circuit of *Fig. 1* be movable so as to permit a mechanical variation of plate spacing, and hence, of capacitance. Let us apply to the terminals of the circuit a small signal voltage of frequency, *s*,— this frequency being equal to the resonant frequency of the circuit—thereby setting up a sinusoidal variation of voltage and also of charge across the capacitor. Imagine now that the upper capacitor plate is suddenly pulled upward a small amount whenever the charge is at a maximum regardless of polarity (this, of course, occurs twice every cycle) and returned to its original position whenever the charge is zero, again twice every cycle. In other words, we are performing a square wave pumping motion with the upper capacitor plate at twice the frequency of the applied signal. This pulling-apart of the capacitor plates, while it decreases the capacitance, does not alter the charge. But for a constant charge, the voltage on a capacitor is inversely proportional to capacitance. Hence, we increase or amplify the signal voltage whenever we increase the plate separation. This "pumping-up" of the signal voltage is also illustrated in *Fig. 1*.

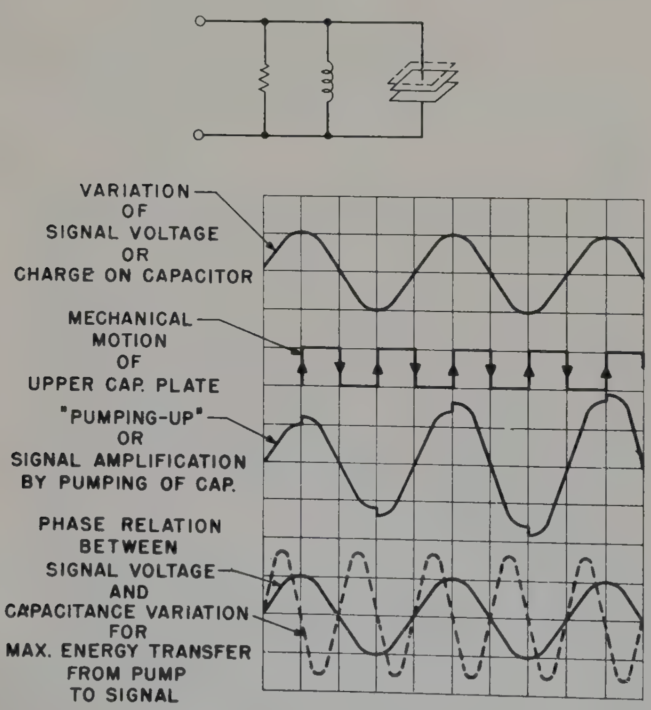

Fig. 1—Illustration of negative-resistance type parametric amplification by means of mechanically pumped capacitor.

Another way to look at this amplification process is to note that we always have to do work *on* the circuit when we separate the plates, since we have to overcome the attractive force between the opposite charges on the capacitor plates, while no work is expended in restoring the original plate separation since this occurs whenever the charge on the capacitor plates and, hence, the attraction between them is zero. The energy transferred in this way from the external pump to the circuit provides the signal gain and internal amplifier losses. Why do we call this type of gain "negative-resistance" gain? Because, like an ordinary resistor, this type of parametric amplifier is a two-terminal or single-port device. In the case of the familiar *positive* resistance the power reflected is always less than the incident power. Conversely, we speak of a *negative* resistance, if the power reflected is greater than the incident power.

A well known example from everyday life of this kind of amplification is a child pumping-up the excursions of a swing. Twice during each complete cycle, that is at both extremes of the swing, the child will raise his center of gravity and lower it during both downward phases of the swing.

In practice, of course, the capacitance is varied not by mechanical, but rather by electronic means and this variation is not square wave but sinusoidal as shown in *Fig. 1* by the dashed sine curve. Summing up: In order to achieve maximum energy transfer from the pump to the circuit, we require (1) that the capacitance be varied at exactly twice the signal frequency, and (2) that this variation be so phased that

the capacitance always is decreased when the charge, and hence the signal voltage, is at an extreme.

In a practical situation it is, of course, very difficult to maintain these exact frequency and phase relationships between an incoming signal, over which we may have little or no control, and our local pump. We will show next that this precise relationship, while necessary for maximum energy transfer from the pump to the circuit, is not required if we are willing to settle for something less than maximum. Let us then examine the situation where the frequency of the incoming signal, *s*, differs from half the pump frequency, *p*/2, as shown in *Fig. 2a*. The result of this difference in frequency is that now the conditions for maximum energy transfer from pump to signal are no longer satisfied all the time. Rather, the pump and signal will periodically drift into and out of the condition for favorable interaction. There will, however, still be a net flow of energy from pump to signal, with the result that our amplified signal will now exhibit a beat phenomenon. It will grow and decay as indicated by the modulated waveform of *Fig. 2b*. A waveform of this type may be shown to be the sum of two uniform sine waves having frequencies *s* and *p-s*, i.e., frequencies equidistant from half the pump frequency. This is an interesting and sufficiently important point to deserve restating: When the signal frequency equals half the pump frequency, we obtain a single amplified output at the same frequency. This case, however, is not realizable because it requires a precise frequency and phase relationship between signal and pump which we cannot realize in practice. If, then, we move the signal off the half-pump frequency, we get back not only the desired amplified signal but also a signal at frequency p-s. This latter signal is known under various names. Some workers, for obvious reasons, call it the "lower sideband" or "difference frequency" signal. Others, having in mind its symmetry with respect to the applied signal about half the pump, refer to it as the "image." Still others, because this signal is a useless by-product of the parametric amplification process, call it the "idler." For the case shown here, where the signal is fairly close to half the pump, the idler has approximately the same amplitude as the amplified signal. As the signal moves further away from half the pump frequency, the relative amplitudes of these two signals change as we shall see later.

There are two important facts we should keep in mind in connection with the image signal.

(1) The image signal is an inevitable by-product of the frequency mixing process which occurs when the signal to be amplified differs in frequency from half the pump frequency, and there is no way of suppressing this image without also suppressing the entire amplification and,

(2) The closer the signal frequency is to half the pump, the closer also is the image to signal and the more difficult it becomes to eventually separate the desired amplified signal from the undesired, but equally strong, image by filtering.

In a practical amplifier, it is therefore desirable to keep the signal frequency a few megacycles away from half the pump frequency. This, of course, means that the parametric amplifier must provide sufficient bandwidth to encompass not only the signal band, but also the equally wide image band plus the guard band. Hence, except for special cases which will be discussed later, the negative-resistance parametric amplifier must provide more than twice the bandwidth occupied by the signal and, as a consequence, accept and amplify more than twice the noise associated with conventional amplifiers.

Let us examine this noise problem a little closer. In *Fig. 3*, the input signal is represented by the short arrow at the bottom with its length corresponding to amplitude, width to the signal band and position to frequency. At the base of this arrow we show input noise, that is, noise which enters the amplifier from the outside together with the desired input signal, as a uniform noise spectrum. The ratio of the length of the input arrow to the length of the black portion at its base represents the input signal-to-noise ratio. The other two arrows are the amplified outputs at the signal and image frequencies. For the moment, we shall assume the amplifier itself to be noise-free, so that the ratio of the length of the output arrow to the black portion at its root equals the corresponding ratio at the input arrow. In other words, signal-to-noise ratio is preserved, at least for noise originating in the signal band. This, unfortunately, is not the whole

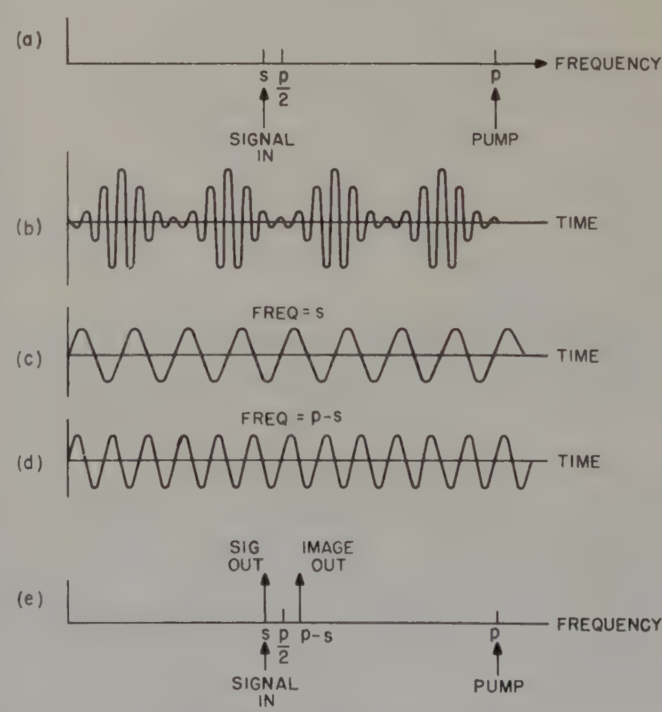

Fig. 2—Illustration of the generation of an image signal for the case when the signal frequency differs from half the pump frequency.

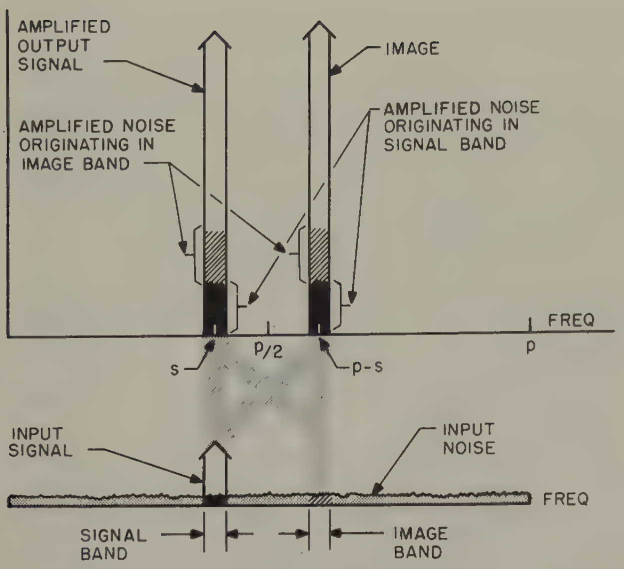

Fig. 3—Effect of image noise in case of ideal (noisefree), negative resistance amplifier is to double noise in signal band.

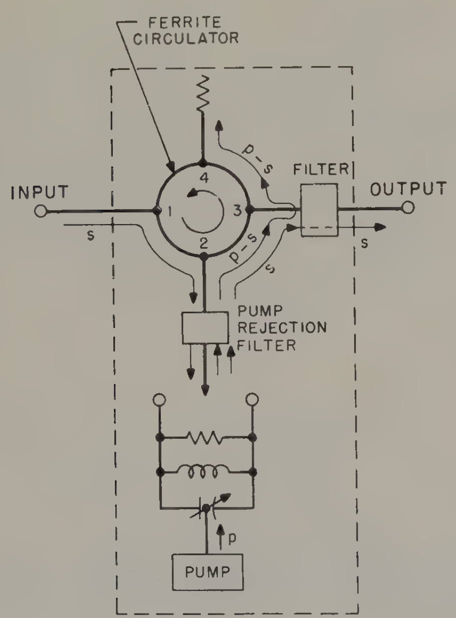

Fig. 4—Typical parametric amplifier arrangement including a ferrite circulator. The circulator serves to separate input from output and also to prevent noise originating in the output load from feeding back to the amplifier and being amplified.

story. Since the amplifier has gain in the image band also, it picks up noise originating in the image band, amplifies it and adds it to the already existing amplified noise in both bands. If we now focus our attention on the signal band, we see that our original signal-to-noise ratio has been degraded by a factor of two in spite of the fact that the amplifier itself has contributed no noise to the amplification process. This type of reception where the signal is introduced in one band only while noise enters both in the signal and image band is called single sideband reception. For the case shown here, namely where both these bands are fairly closely grouped around the half pump frequency, the best noise figure we can obtain is 3 *db*.

It is all the more surprising that, in spite of this 3 *db* handicap, we can still realize noise figures in practice which compare favorably with the best low-noise tube amplifiers. This, as we shall see later, is due primarily to the excellent low-noise properties of the variable-capacitance diode itself.

It is of interest to note here that there is a type of signal for which we do not have to pay this 3 *db* penalty in noise figure. This is for the type of signal encountered in radio astronomy, i.e., where the signal itself is incoherent noise. This noise signal may now be introduced not only in the signal band but also in the image band. Thus, the effect of the image response is to transfer into the signal band not only noise but also useful signal so that, for the case of an ideal amplifier, signal-to-noise ratio is preserved.

The reader may justly wonder at this point how, in a practical situation, the four signals we have encountered so far, namely, the input signal, the amplified output signal, the image and the pump, are unscrambled and input isolated from output. The most commonly used method is illustrated in *Fig. 4*. It makes use of another solid state device, the ferrite circulator. By the action of this device the signal to be amplified is introduced at terminal 1 and guided over to terminal 2 where it enters the parametric amplifier and is amplified. The amplified signal, together with the image signal, re-emerge at terminal 2 and are guided over to terminal 3. Here, they encounter a filter which is transparent to the amplified signal but totally reflective to the image. Terminal 3, therefore, becomes the effective output terminal while the image signal is guided over to terminal 4 where it is harmlessly dissipated in a termination. The strong pump signal is confined to the variable capacitance and prevented from leaking into the output by a sharply-tuned pump rejection filter which may be inserted between the amplifier and terminal 2 of the circulator.

It is important that the amplified signal and idler proceed along the paths indicated in *Fig. 4* without suffering partial reflections either at the pump rejection filter or at terminal 2 of the circulator. Such reflections, if they occur, could either add or subtract from the original signal and thereby cause an undesired change in gain, or, if they are strong enough and of unfavorable phase, induce oscillations. Gain stability, therefore, requires that the match presented to the amplifier terminals be an excellent one, over both the signal and image band.

Variable-Capacitance Effect in Semiconductor Junction Diodes

The variable-capacitance diode constitutes the real heart of the parametric amplifier. In practical amplifiers it plays the role of the mechanically-pumped capacitor discussed earlier in connection with the low-

frequency analog. To explain the operation of this important circuit element, we shall go through a fictitious process of assembling a p-n junction. At the top of *Fig.* 5 we see two sections of semiconductor material. In the n-type section on the left, the circled plus signs represent fixed positive charges due to donor impurities, and the minus signs mobile negative-charge carriers or electrons. In the p-type section, the circled minus signs represent fixed negative charges due to acceptor impurities, and the plus signs mobile positive-charge carriers or holes. By themselves, both slabs are electrically neutral, i.e., in the n-type material the fixed positive charges are neutralized by precisely the same number of electrons and, similarly, in the p-type material, the fixed negative charges are exactly neutralized by the same number of holes. Let us now bring the two slabs into contact to form a p-n junction as in *Fig. 5b* and observe the events preceding the establishment of equilibrium in slow motion.

With the p and n sections in contact, electrons will diffuse from a region of high to one of low electron density, that is from the left to the right and, similarly, holes will diffuse across the junction from the right to the left. As this diffusion proceeds, the loss of electrons will render the previously neutral n-type section increasingly positive. Similarly, the diffusion of holes from the right to left will render the p-type section increasingly negative. The potential difference between the two halves will result in a potential gradient or electric field at the interface (see solid curve in *Fig. 5c*), so directed as to oppose and finally bring to a halt the diffusion of electrons and holes across the junction. As another consequence of this electric field, a narrow region about the interface will be swept clear of electrons and holes, thus giving rise to the charge carrier distribution for an open-circuited or zero-biased diode shown in *Fig. 5d*. Because it is devoid of mobile charge carriers, this central layer, usually referred to as the depletion layer may be thought of as a nonconducting or dielectric region. It is bounded on either side by regions which do contain mobile charge carriers and, hence, may be considered conducting regions. Thus, we may define an equivalent parallel-plate capacitor *(Fig. 5e)* having a plate separation equal to the depletion-layer width.

Next suppose the junction is given a slight reverse bias, i.e., a bias so directed as to increase the potential difference between left and right (see dashed curve in *Fig. 5c)*. The positive potential applied to the n side (see dashed plus sign) will then urge the electron distribution toward the left, while the negative potential applied to the p side will urge the hole distribution to the right. The result of this moving-apart of the charge carrier distributions will be a widening of the depletion layer and a decrease in terminal capacitance. Similarly, a forward bias will urge the carrier distributions toward each other, the depletion layer will shrink and the capacitance will increase. Thus we have here a capacitor whose terminal capacitance will vary with the applied voltage.

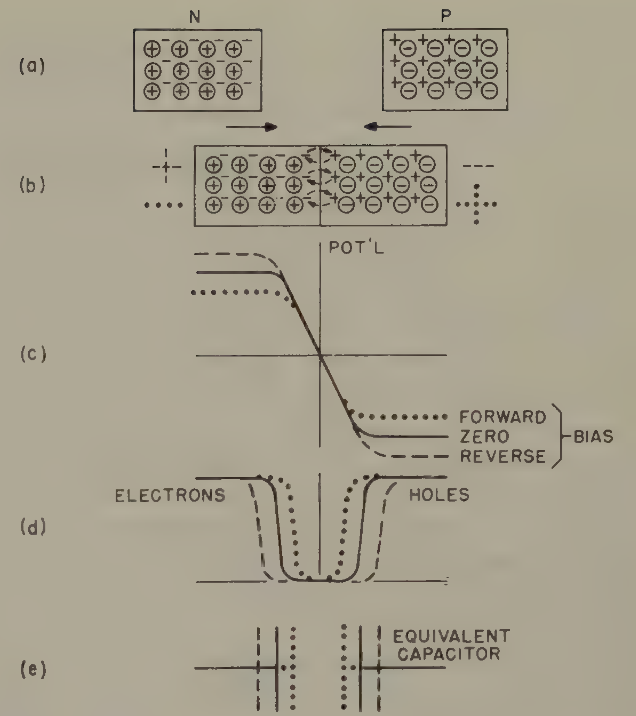

Fig. 5—Variable-capacitance effect in a semiconductor junction diode.

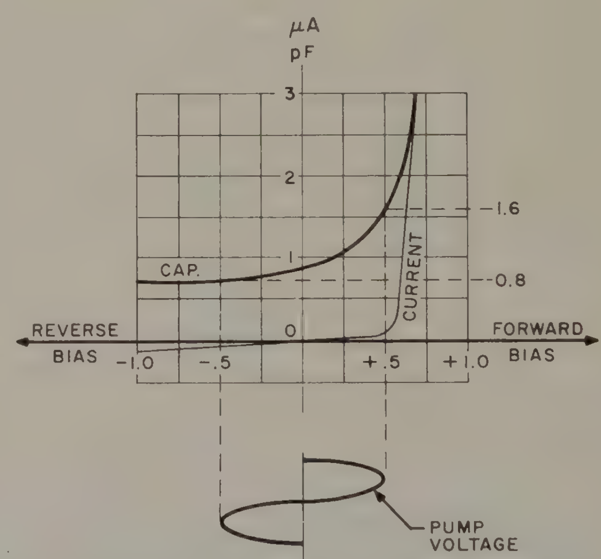

Fig. 6—Capacitance-voltage and current-voltage relationship for typical variable-capacitance junction diode.

It is very important to bear in mind in this connection that 1) this variation in capacitance results from a very minute motion of electron and hole distributions, that is, a motion of only a few millionths of an inch, and 2) an actual flow of charge carriers across the junction is not involved. These are the principal reasons which make the variable-capacitance diode such an excellent device both for high-frequency operation and for low-noise while the transistor, though consisting of the same materials, is not notable for excellence in either respect.

The capacitance-voltage relationship for a silicon *p-n* junction diode of good quality is shown in *Fig. 6*. Also shown (dashed) over the same range of voltages is the conduction current. We see that over most of this range the conduction current is negligibly small, i.e., less than half a microampere. The pump voltage is usually applied about the zero bias point and for a peak-to-peak amplitude of one volt may typically result in a 2:1 capacitance variation.

How about the frequency dependence or frequency limitation of this variable capacitance? There are no limitations known to us at present. The actual change in depletion layer width under the influence of the applied voltage is so minute, only a few millionths of an inch, that transit time effects are indeed negligible up to the highest frequencies of present-day interest. Long before we reach transit time effects, however, we encounter another frequency limitation. This may be seen from the equivalent circuit of the diode at the top of *Fig. 7*. Here, $C(V)$ represents the variable part of the capacitance just described and C the fixed terminal capacitance we measure with zero bias. C is a function of the contact area, depletion layer width, the applied bias and the type of encapsulation. R_s represents the spreading or series resistance of the diode; it is due to the impedance of the bulk of the semiconductor material to the flow of majority carriers. Now, it is clear that at a sufficiently high frequency the fixed capacitance, C, will effectively short out the variable capacitance so that all of the applied voltage will then appear across and be wasted in the series resistance. M. Uenohara has shown that the highest frequency at which amplification can be obtained is given by the simple relation

$$f_{s\ max} = \frac{1}{2}\ \frac{1}{2\pi C\, R_s}$$

At this frequency the negative resistance generated by the variable capacitance is exactly equal to its series resistance.

The principal noise contributed by the variable capacitance diode is thermal noise originating in R_s. The effect of this noise increases with increasing frequency as does the fraction of the signal voltage which appears across the series resistance. The noise performance of the variable-capacitance diode therefore deteriorates at high frequencies. In this connection, recent experiments at Bell Telephone Laboratories and Hughes Laboratories have shown that this noise contribution, small as it is, can be further reduced by refrigeration. Down to liquid nitrogen temperature, i.e., about 70°K, no change in resistance and hence a considerable improvement in noise performance was observed.

Another factor which makes the noise performance of this diode so attractive is that the variation of capacitance does not involve the flow of charge carriers across the junction. Hence, we would expect shot noise to be negligible. This has indeed been confirmed theoretically by Uhlir.

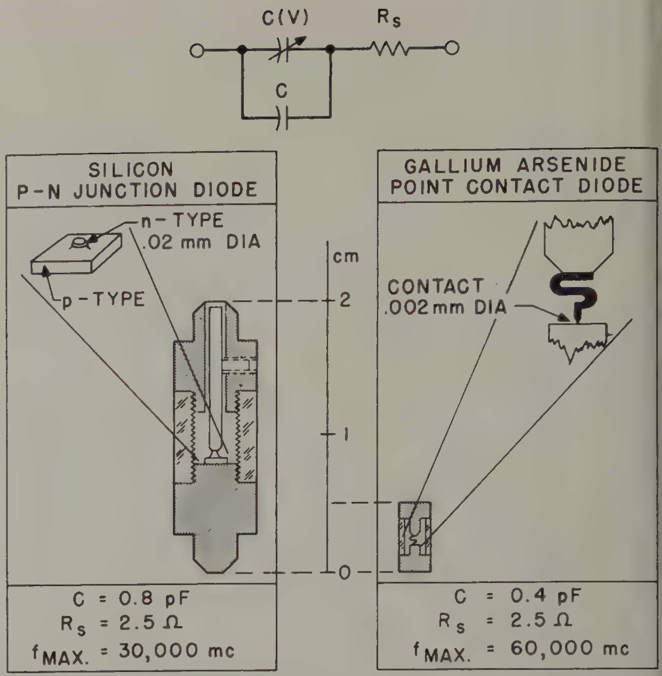

Fig. 7—Equivalent circuit and constructional features of junction-type and point-contact variable capacitance diodes.

A typical silicon *p-n* junction diode is shown on the left of *Fig. 7*. The active part consists of a *p*-type silicon base with a small cylindrical projection (mesa) of *n*-type material having a diameter of approximately .02 mm. The wafer is soldered to a metal base and pressure contact is made to the mesa by a metallic post. The entire arrangement is enclosed in an evacuated metal-ceramic cartridge.

Another type of diode which has aroused a great deal of interest during the more recent past is a point contact diode made of gallium arsenide. This diode was originally developed by W. M. Sharpless at Bell Telephone Laboratories as a millimeter wave detector but tests by Uenohara have shown it to possess excellent noise properties at room temperature and to be capable of refrigeration down to liquid nitrogen temperature with consequent further improvements in noise. Also, because of its lower fixed capacitance, it can be operated at higher frequencies than the junction diode. The active part of this diode consists of a GaAs base to which contact is made by means of a phosphor bronze spring having a contact area 1/100 that of the junction diode, i.e., a diameter of only .002 mm. The encapsulated diode shown on the right of *Fig. 7* may be seen to be very much smaller than the junction diode.

Comparing the relevant parameters of these two diodes, we see that the capacitance of the GaAs diode is about half that of the junction diode, the spreading resistance about the same and the highest amplification frequency consequently twice that of the junction diode.

(To be continued)

A Survey of Semiconductor Devices and Circuits in Computers

Part 2

VELIO A. MARSOCCI*

Basic Logic Circuitry

In a discussion on switching circuits it is necessary to define the logic[11] which the circuit operation is to represent. That is, the circuit logic depends on which circuit state is made to correspond to the binary "0" or "1". For instance, the absence of a pulse or signal level may be defined to mean "0," and the presence of a pulse to have the meaning "1," or the opposite arrangement may be used. There also exist the possibilities of defining "0" and "1" by two different *d-c* levels (non-zero), of the same polarity, or by negative and positive pulses, or by any consistent combination of potential levels and polarities. In the present discussion it will be assumed that either a zero or a negative *d-c* level with respect to ground will represent a "0," and that a "1" will be represented by a *d-c* voltage positive with respect to ground. Also, the "presence" of an input "A" will be written as A, and "not A" will be indicated by $\overline{A}$.

The simplest and most economical form of logic circuitry, from the standpoint of number and type of components, is diode logic circuitry.[9,11] *Fig. 5* shows a typical arrangement for a diode *and* gate and a diode *or* gate. When no input pulse is applied, it is assumed that the input of the diode is returned to ground or to a negative potential. The *and* circuit produces a positive output only when a positive signal level is applied to all the inputs, but the output will be at ground potential if any of the inputs has no positive signal level (pulse) applied. That is, the output level will be placed near ground potential through any of the diodes which may be conducting.

The operation of the *or* circuit follows a similar line of reasoning except that the output of the circuit will be positive if any of the inputs has applied to it a positive voltage, and will be near ground potential if none of the inputs have a signal applied.

The disadvantages of the diode gate circuits are, first, if the output of one of the diode gates is required to provide one of the inputs of a second gate the loading effects due to the diode characteristics, as well as the problem of *d-c* biasing, represent a serious limitation on the complexity of the diode circuitry; and second, since no gain is available in a conventional diode, a loss of signal level is incurred through subsequent stages, thereby limiting the number of stages which can provide a useable output.

The required isolation between stages and the desired gain may be provided by incorporating transistors [10,11] in the circuit as shown in *Fig. 6*. Here, the transistors are driven into conduction by a positive level at their bases, in which case the potential at the output of any conducting transistor is near ground. The absence of a positive signal at the base of any of the transistors shown results in that transistor being cut-off and its output will therefore be at a positive *d-c* level. Notice that the use of a common-emitter connection, although requiring less driving power and providing gain, results in signal phase inversion and reduced switching speeds (from Equation 5, f_{ae} is less

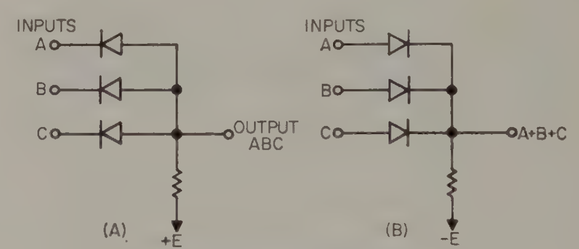

Fig. 5—D-C diode gates.

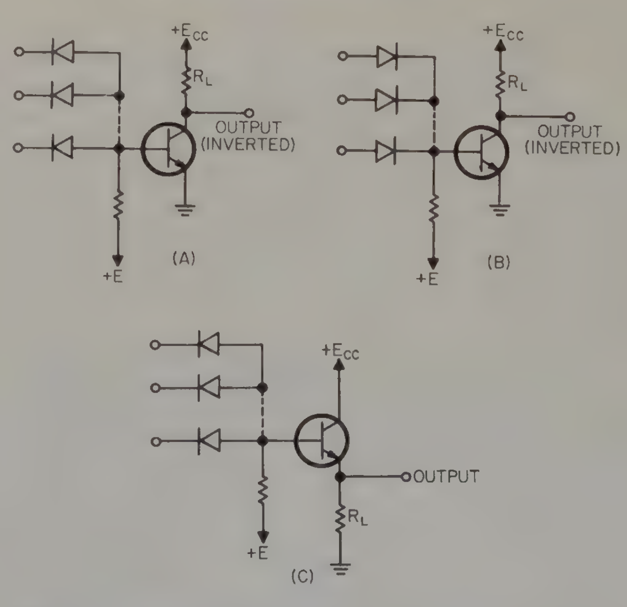

Fig. 6—D-C gates employing diodes and transistors.

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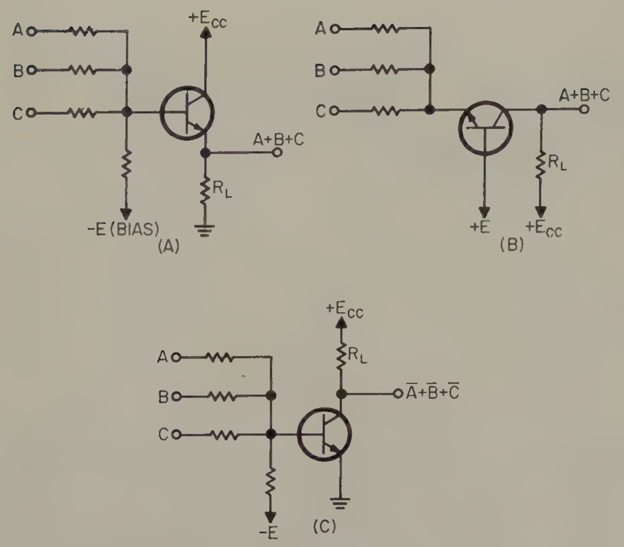

Fig. 7—"*or (and)*" and "*nor*" gates.

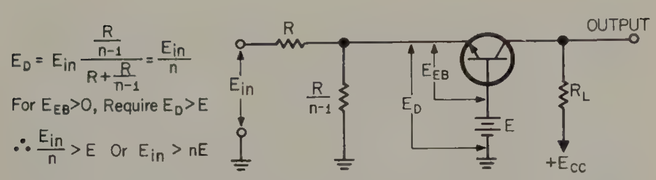

Fig. 8—Condition on input signal for switching single-transistor "*or*" gate.

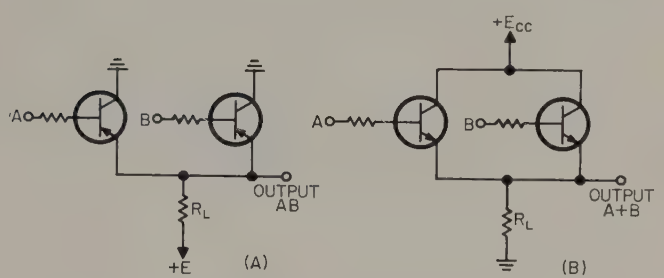

Fig. 9—Multiple-transistor gating circuits.

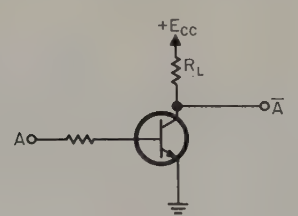

Fig. 10—"*not*" gate.

than f_{ab}). The phase inversion may be compensated for by the subsequent phase inversion of a succeeding stage in the computer system, or by the use of an additional common-emitter stage following the gating circuit. This inverter stage may be the *not* circuit shown in *Fig. 10*. It should also be noticed that the time delay due to the transistor's switching characteristics is now added to the delays due to the diodes.

Phase inversion may be eliminated by employing the transistor in a common-collector arrangement as shown in *Fig. 6c;* or if an increased switching speed is required a common-base connection may be used. However, both the common-collector and the common-base arrangements suffer from the viewpoint of providing gain. The common-collector connection provides no gain in voltage.

An additional advantage in circuit economy may be realized by the use of resistance-coupled circuits, although somewhat greater care is required in selecting the biasing arrangements for proper operation. *Fig. 7a* shows a single transistor common-emitter *or* gate where the input coupling is provided for by the use of resistors. A positive signal applied at any of the inputs with sufficient magnitude to overcome the effect of the threshold bias voltage *-E,* will cause the transistor to go into conduction, thereby producing a positive output level. It should be noted that if the circuit is to operate as an *or* circuit then an input voltage applied to any one of the resistors, with all the other inputs at ground potential (no signal condition), must be capable of switching the transistor.

The common-base circuit shown in *Fig. 7b* operates such that the biasing keeps the transistor conducting if no input signal is applied. The collector is then at some low potential near ground. If the circuit is to operate as an *or* gate then a positive signal to any one of the inputs must be capable of switching the transistor *off*. The *off* condition for an *n-p-n* transistor requires that its emitter must become positive with respect to its base, and therefore the input voltage E_{in}, applied to any one of the inputs in *Fig. 7b* must be such that $E_{in} > nE$. The derivation of this condition is illustrated in *Fig. 8*. It is assumed in the analysis that there are n input resistors each of resistance R. Further, one of the resistors has an applied signal, and those with no signal applied may be replaced by an equivalent resistance equal to $R/(n\text{-}1)$. Similar techniques may be applied to determine the bias and input conditions for the other circuit arrangements.[11]

It may also be noted that by increasing the biasing level and adjusting the input voltages so that the transistors will switch only if n inputs are applied and will not switch if n-1 or less inputs are applied, all the *or* gates previously described become *and* gates.

The circuit shown in *Fig. 7c* is a modification of that of *Fig. 7a*, and is referred to as a *nor* circuit.[10] If the bias voltage, —*E,* for this circuit is adjusted such that the transistor conducts only if there is a positive level at all three inputs simultaneously then the circuit performs the operation *not A—or not B—or not C* since the absence of a positive pulse at any one of the inputs will cause the transistor to cease conducting thereby raising the output to some positive potential point signifying an output "1". The importance of the *nor* circuit lies in the fact that *nor* logic can be used to synthesize most of the logical operations required by a computer. For instance, an *and* operation is performed if negative input signals are used, with a positive biasing potential applied to

the base of the transistor. The biasing is set such that the transistor is cut off only if there is a negative input signal applied to each input simultaneously. Obviously phase inversion is performed if the gate is used with a single input such that the presence of a positive input signal switches the transistor into conduction. Looking ahead, from an inspection of *Fig. 15c* it may be observed that two single-input *nor* gates may be connected to form a flip-flop. The further advantage of *nor* logic is that the circuitry is composed of a minimum number of simple components leading to more reliable and relatively inexpensive computer circuit designs. The disadvantage[10] associated with this type of circuitry lies in the fact that the operation is limited to low-and-medium frequency switching applications. This limitation is brought about by having several inputs applied which may drive the transistor hard into saturation. However, improved switching times are available through the use of high-frequency transistors, but with an attendant loss in circuit economy.

Variations on the *and* and *or* circuits which require more transistors, but which have lower driving power requirements than the single transistor gates, are shown in *Figs. 9a* and *9b*.[11] In these multiple transistor circuits each input has its own associated transistor, and the input voltage requirement is such that it is only necessary to overcome the voltage divider action of a single input resistor to switch the transistor. In the circuit of *Fig. 9a,* the transistors are biased in the *on* state so that the output remains near ground. Only when both transistors are cut off by positive inputs will the output rise toward the positive voltage $+E$. The *or* gate shown in *Fig. 9b* is biased in a manner to keep the transistors in cutoff. If an input signal causes either transistor to conduct, then the output will rise to a positive potential near $+E_{cc}$. In the *not* gate of *Fig. 10,* a positive input potential will send the transistor into conduction resulting in an output level at ground potential. The absence of a positive input will cause the collector to rise to a positive voltage level. Thus, a *not* operation is performed.

The concept of the "presence" of an output indicating the "absence" of an input is performed in a digital system by the use of inhibit gates as indicated in *Fig. 11.* In this circuit, the output rises to a positive level only if there exists a positive input at A and not at B. That is, if the transistor switches *on,* the potential of the collector will move toward the positive potential of the signal at input A. An *exclusive or* operation, that is, one indicating "the presence of A and not the presence of B, or not the presence of A and the presence of B," may be implemented by combining two inhibit gates as illustrated in *Fig. 12.* In this arrangement there will be an output only if there is a positive signal at A and none at B, or if there exists a positive signal at B and none at A.

The operation of partial summing with the production of a "carry" indication is carried out by the use of a *half adder* circuit. A block diagram of a *half adder* is shown in *Fig. 13* where the previous *exclusive or* circuit is combined with an *and* gate to perform the operation indicated in the diagram. The "carry" output, if one is produced, is used as an output to successive logic circuits in the system to indicate the presence or the absence of the "carry" operation during some part of the computation involved. The operation of the circuit is described by a positive level at output 1 only for the *exclusive or* combination, and a positive level at output 2 only if a positive input exists simultaneously at A and B.

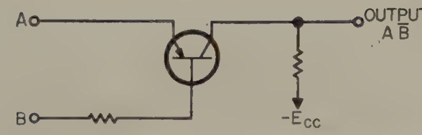

Fig. 11—Single-transistor *"inhibit"* gate.

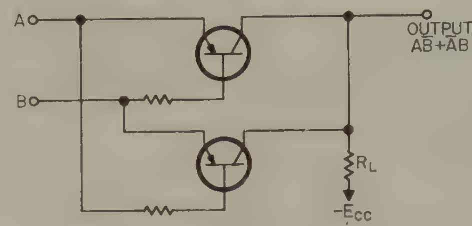

Fig. 12—*"Exclusive or"* gate.

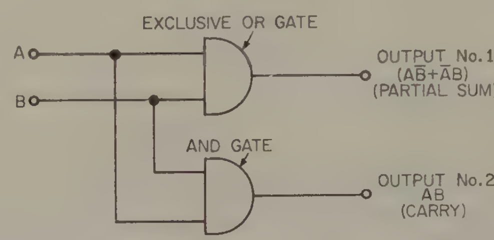

Fig. 13—Half adder.

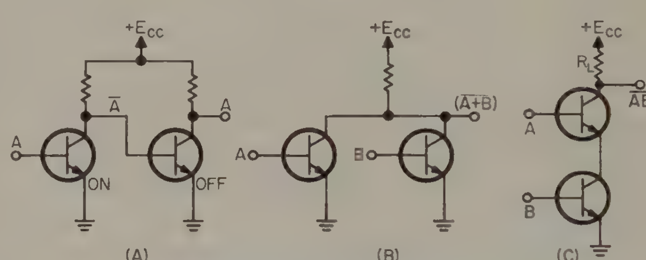

Fig. 14—DCTL circuits.

Direct-Coupled Transistor Logic (*dctl*) Circuitry

The direct-coupled transistor logic circuits[9, 11] are formed by direct coupling the transistors, without the use of interstage resistors, in such a manner that the circuits perform logical operations similar to those previously described. *DCTL* circuits provide the required logic with a minimum number of component types generally arranged in very simple configura-

tions. The omission of interstage components also reduces the power dissipation requirements considerably. Some typical *dctl* circuits are shown in *Fig. 14. Fig. 14a* shows a basic series connection where a positive input level at A drives the first transistor *on* placing its collector potential near ground. If the saturation collector-to-emitter potential of the transistor is low enough, the second transistor will be held *off* due to its base potential being essentially near ground. A whole series chain of these circuits may be connected with alternate *on* and *off* conditions, provided there is sufficient current gain in each of the transistors so that the resultant current into the base of an *on* transistor will drive that stage into saturation. The circuit shown in *Fig. 14b,* referred to as a "parallel gate," operates in a manner such that the presence of a positive input potential applied to input A or to input B (or both) will result in the output potential being placed near ground through the conduction of the transistors to which the inputs are applied. According to the logic previously mentioned this would result in an inverted *(not)or* output. The circuit of *Fig. 14c,* known as a "series gate," has its output at ground potential only if both transistors are conducting, that is, if a positive input signal exists at both A and B. This describes an inverted *(not)-and* operation. Notice that the potential applied to A which will cause conduction in the upper transistor must be somewhat higher than that required at B for conduction in the lower transistor. Notice also that the emitter of the lower transistor must be capable of handling the emitter current (base current plus collector current) of the upper transistor, plus its own base current.

It is evident that certain disadvantages accompany the use of *dctl* circuitry. Although the circuit configurations are simpler than those of the previously discussed logic circuits (i.e. diode and resistance-coupled circuits), the tolerances on the transistors are more stringent for the *dctl* circuitry. Besides the requirement of a low collector-to-emitter saturation voltage, a certain uniformity in the input requirements for the transistors is also necessary. For example, the output of one of the circuits described in the previous paragraph might be needed to drive several succeeding stages. If each of these succeeding stages required different input potentials to switch *on,* then it is obvious that one or more of the transistors may take over the drive current by being the first to conduct, thus possibly preventing the other transistors, being supplied by the same input, from achieving full conduction. It should also be noted that due to the comparative absence of external circuitry, the switching time for *dctl* circuits is almost entirely a function of the transistor characteristics.

Regenerative Switches

The operations of pulse generation, timing, short-time-memory storage and counting are implemented in digital systems almost entirely by the use of multivibrator type circuits.[4,10,11,17,19]

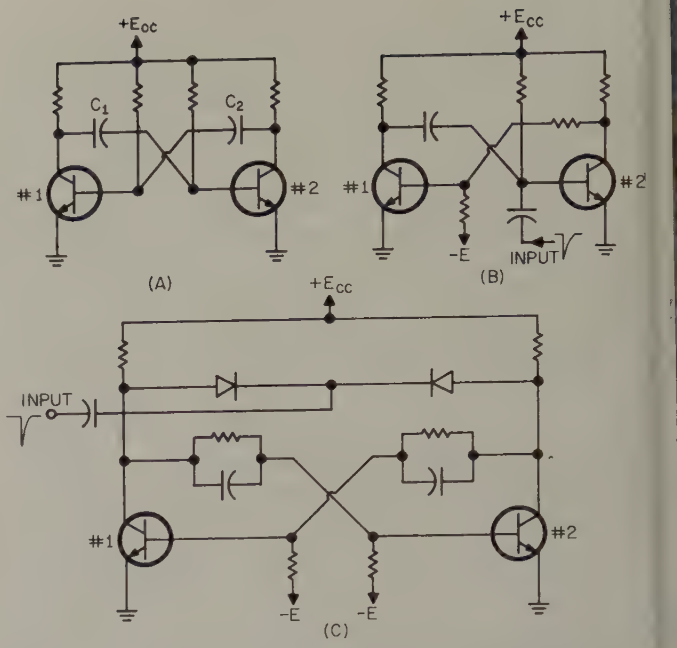

Fig. 15—Conventional saturating multivibrators.

The operations of clock-pulse generation and of frequency division are usually performed by the use of astable (free-running) multivibrators. The monostable type of multivibrator performs in a manner similar to the astable type except that it must be triggered from one stable state to another by an input pulse for each switch-over. The multivibrator circuit which finds greatest application in digital computers, however, is the bistable multivibrator circuit, or flip-flop. The operation of the flip-flop enables it to be used as a register for binary digits, resulting in short-time memory storage. The flip-flop also forms the basic element in most counting networks.

Fig. 15 shows the basic circuit configurations of the multivibrators mentioned above. It is assumed in these circuits that when a transistor is in an *on* state, it is being overdriven into saturation. In this manner its saturation collector-to-emitter voltage is low enough to hold the opposite transistor in its *off* state. Circuits of this type are referred to as "saturating" multivibrators.

A basic free-running multivibrator is shown in *Fig. 15a.* To start the action assume that transistor 1 is *on* and transistor 2 is *off*. Therefore, the collector potential of the *on* transistor is near ground. The charge on *C1* is small while *C2* charges to essentially the value of E_{cc}, turning on transistor 2 and driving transistor 1 into cutoff. The cycle then repeats itself. The repetition rate of the action is determined by the time constants of the base resistor-capacitor and the collector resistor-capacitor combinations.

The monostable version is indicated in *Fig. 15b.* In this circuit transistor 2 will be in the *on* state with the other transister held *off*. The circuit will remain

in this state until an input pulse triggers the circuit into the opposite state. That is, the *on* transistor is switched *off* and the other transistor is switched *on*. This state is maintained for a time duration determined by the value of the R and the C, and then the circuit switches back to its original condition. In this manner a "one-shot" pulse is generated.

The flip-flop circuit shown in *Fig. 15c* will remain in either of two possible states, i.e. transistor 1 *on* and transistor 2 *off* or vice-versa, until it is triggered into the opposite state. The operation of the flip-flop, in switching from one state to another is similar to that described for the other multivibrator types, except that here the coupling circuit arrangement is such that the particular state to which the circuit is switched is maintained until the next triggering pulse arrives. The diodes in the circuit are necessary in order to insure that the negative input pulse which is required here for triggering is "steered" to the *off* transistor and is prevented from being by-passed through the *on* transistor. It is evident then, that the particular state of a flip-flop may be identified with a memory of whether or not a pulse arrived during some previous time intervial. In digital systems several flip-flops may be arranged to handle complete binary numbers composed of many digits.

In the saturating multivibrators the switching speeds are affected in a manner identical to those of the simpler non-regenerative switching circuits previously described. That is, driving the transistors into saturation in an attempt to decrease the turn-on time of the switches results in increased storage effects which then limit the minimum pulse times which the particular multivibrator can handle. *Fig. 16* shows a circuit arrangement for a non-saturating flip-flop where collector clamping is provided for by the use of diodes. The non-saturating circuit then enables greater switching speeds with reduced storage time effects. However, the diode time constants must also be taken into consideration in the non-saturating circuits. The switching speeds of the multivibrators may be increased further by the use of additional transistors to provide switching power as well as to provide a better impedance match between a collector and the base of the opposite transistor. A circuit of this type is shown in *Fig. 17*.

The flip-flop circuits discussed here represent only a small number of all the circuit variations possible. For instance, triggering may be applied to either the base or to the emitter instead of to the collector. Several methods of clamping may be used, and the circuit possibilities for trigger-pulse steering and trigger-pulse amplification are many. The different circuit configurations possible are too numerous for inclusion in the present discussion and the reader is referred to the literature where some of these circuits are described.[6, 10, 11, 19]

A common application of flip-flops in computer systems is illustrated by the two stage flip-flop binary counter shown in *Fig. 18a*. The circuit shown is a

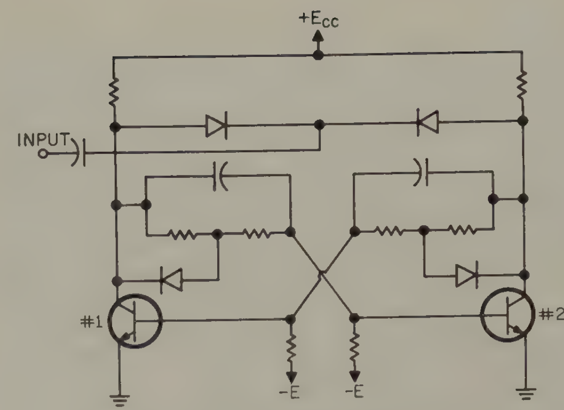

Fig. 16—Non-saturating flip-flop.

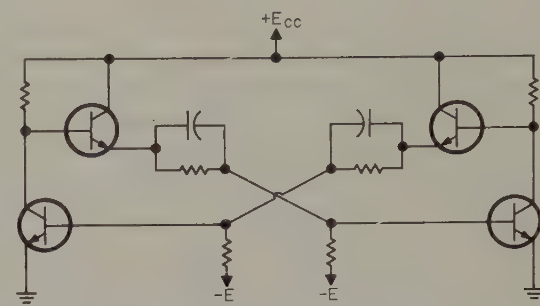

Fig. 17—High-speed flip-flop.

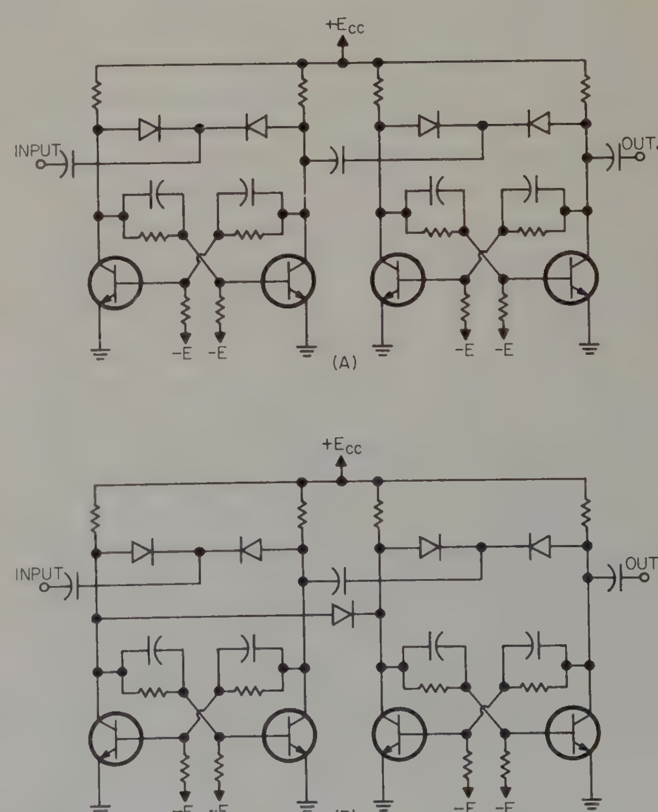

Fig. 18—Flip-flop applications in digital computers.

count-by-four connection.[19] Notice that two input pulses are required to produce a complete pulse at the output of the first circuit and two of these output pulses are required, in turn, to produce a pulse at the output in the second stage. Thus, every four input pulses to the first stage will produce one pulse at the output of the second stage. It then follows that if n flip-flops are cascaded, 2^n input pulses are required to produce one output pulse. By making appropriate feedback connections it is possible to construct circuits which will count in other than binary steps. For example, a count-by-three circuit[19] may be constructed by modifying the count-by-two circuit with the inclusion of a feedback diode as indicated in *Fig. 18b*.

Another important application of the flip-flop is in the shift register circuits of digital computers. As has been previously mentioned, the shift register may be used to shift the position of a set of binary digits, as a short-time-storage memory or to convert binary information from a serial to a parallel representation. A shift register operates in such a manner that for each input pulse applied simultaneously to the stages each stage will "shift" to the state held by the preceding stage prior to the application of the input pulse. By referring to the diagram, it may be seen that the state of any stage is determined by the state of the previous stage, and the direction in which an input pulse is gated will be a function of the condition in the preceding stage. Although the input pulses are applied in series, with respect to time, it should be noted that by sensing simultaneously at each of the output terminals the state of the shift registers may be read off in a parallel fashion.

Presently available components make it possible to obtain relatively high speed switching circuits. Some typical values obtained from the switching performances of circuits utilizing commercially available high-frequency transistors of the diffused-base mesa type are: rise and fall times of approximately 5 to 20 mμsec with overall pulse times of 25-120 mμsec for pulse magnitudes near 10 volts, and up to 25 *mc* repetition rates for saturating flip-flop circuitry.

It is also possible to extend the concept of direct-coupled logic to regenerating switching circuits.[9, 11] In *Fig. 20,* a typical *dctl* flip-flop circuit is shown whereby the external coupling circuitry between the transistors has been omitted. In this circuit it may be assumed that transistor 1 is originally *off* and transistor 2 *on*. If a positive input to the driver causes the driver to conduct then the collector of transistor 1 is placed near ground potential. The action will turn transistor 1 *off* and transistor 2 *on*. A similar driver may be connected to the collector of transistor 2 to perform a re-setting operation. The switching speed is determined here primarily by the transistor parameters. It is obvious that either collector may be used as an output or an input terminal. The circuit configuration is such that the voltage levels at the collector will vary by only a small fraction of a volt from the *off* to the *on* condition, so that the circuit lends itself more to a current type of logic rather than to a voltage logic scheme.

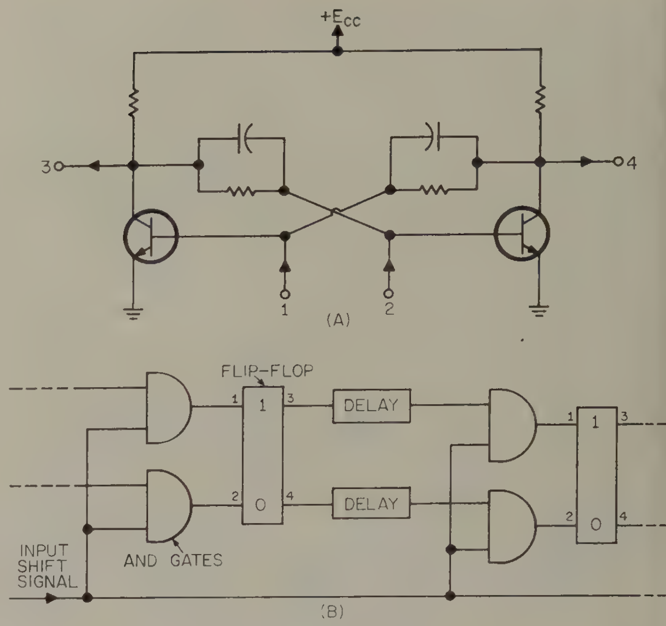

Fig. 19—Shift register. (A) Single-stage flip-flop showing shift-register connections. (B) Shift register composed of coupled stages.

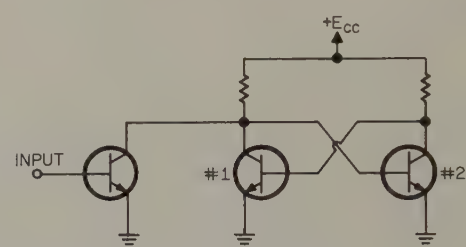

Fig. 20—DCTL flip-flop.

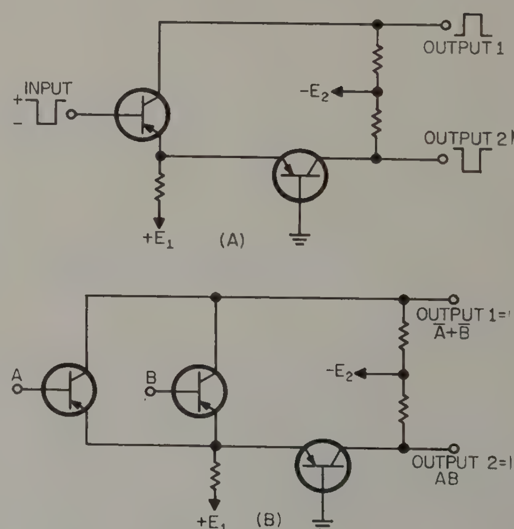

Fig. 21—Current switching circuits.

Current Switching

An increase in switching speeds with some reduction in noise generation is possible by utilizing transistor switches in a current-logic mode.[10] The current-logic type of operation is characterized by switching between two distinct current levels with the use of a small input signal. A basic current switching circuit is shown in *Fig. 21a*. Here, a negative input signal drives transistor 1 into conduction so that its collector potential rises. The same negative input acts in a manner to bias transistor 2 *off* causing its collector potential to become more negative. Logic circuits based on a current-switching mode of operation may be constructed as shown in *Fig. 21b*. In the circuit shown a negative input at A or at B will result in an increase of potential at output 1. This may be interpreted as a point in the circuit from which an inverted *or* output may be taken. However, at output 2 there will result a decrease in potential for a negative input at any one of the inputs (or at neither A nor B) and an increase in potential only if there is a positive input signal at both A and B. Thus output 2 represents an *and* operation which is non-inverted. In a similar manner circuit arrangements can be made so that all the switching operations previously described on the basis of voltage switching may be performed by a current-switching mode of operation as well. The apparent disadvantage of current-switching circuits lies in the need for a large number of transistors per stage as well as in the necessity for more than one power supply.

(To be continued)

Microphotographs for Electronics

T. C. HELLMERS, Jr.* J. R. NALL†

The Diamond Ordnance Fuze Laboratories has designed and built two cameras to prepare microphotographs for the fabrication of semiconductor devices and microelectronic solid circuits by photoengraving and photomechanical techniques. These cameras are capable of taking a variety of patterns and combining them in precise sizes and shapes to make masks that can be used to transfer patterns to semiconductor and other solid-state materials. A reticle camera will make patterns covering a 1-inch-square area with a maximum resolution of 200 lines per mm. A step-and-repeat camera is very restricted in area covered but will resolve patterns in the micron range (1 x 3 microns) and is capable of locating patterns in precise geometric positions over a 1 x 3 inch plate with an accuracy of ± .0001 inch. A spectroscopic plate #649 GH, 1 x 3 inches, has been used for making these patterns. It has a resolution of 2000 lines per mm. Patterns made with these cameras have been used in the fabrication of individual transistors and diodes, multiple diodes and transistors, semiconductor elements of complex geometry, and evaporation masks.

THE FIELD OF MICROPHOTOGRAPHY has a long history, dating as far back as 1839. During the past 50 years microphotography has found use in various scientific areas such as data processing, espionage documents, production of reticles, motion and still pictures (8 mm, 10 mm)[1] and in the manufacturing of photomechanical aids. This article describes an application of microphotography to the production of solid-state devices and microelectronic elements and circuits.

Basic Microphotographic System

Microphotography is the art of making minute images from large originals. Loss of sharpness which results from reduction of image size is minimized by using slow fine-grain film, and by employing only the center of the field of the objective lens. The Lippmann type

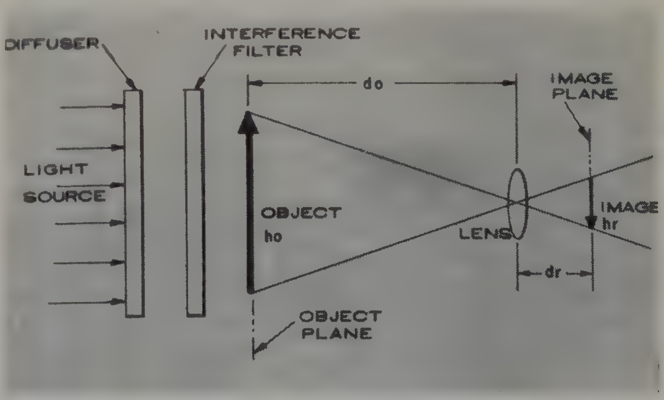

Fig. 1—The degree of reduction h_o/h_r equals the objective-to-object plane distance divided by the objective-to-image plane distance.

[1]G. W. W. Stevens, "Microphotography—Photography at Extreme Resolution," John Wiley & Sons Inc., 1957.

*Dept. of the Army, Ordnance Corps, Diamond Ordnance Fuze Laboratories.
†Formerly of DOFL, now at Fairchild Semiconductors Inc., Palo Alto, Calif.

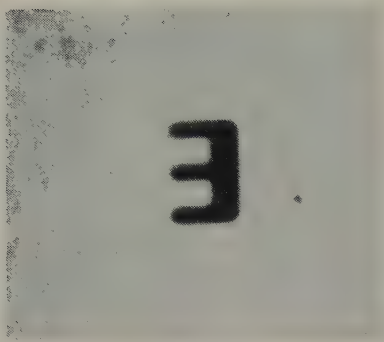

Fig. 2—Conventional cameras require too many steps causing loss of resolution. Note round corners and general diffusion of pattern.

of film emulsion is preferable.[2] This emulsion has a resolution of approximately 2000 lines per mm. Microscope objectives can be used in the optical system, best results being obtained with apochromatic lenses and monochromatic light sources. *Fig. 1* illustrates the optical system employed to obtain the resolution mentioned above.

Description of Optical System and Equipment

In October 1957, DOFL constructed the first circuit incorporating transistors and diodes as integral parts by photoengraving and photomechanical techniques.[3] In making these patterns, standard copy camera and emulsions were used. These cameras reduce images a maximum of 6X in one step. The drawing was made 100X with sharp corners and straight edges. After three reductions on a camera, considerable loss of resolution occurred as shown in *Fig. 2*. Conventional cameras and emulsions have a maximum resolution under ideal conditions of 300 lines per mm for the lens and about 200 lines per mm for the emulsions. To obtain precise sizes, maximum resolution, and best definition of edges, the objects (patterns) should be aligned on the optical axis, and emulsions of highest resolution and greatest density (for maximum contrast) should be used.

In order to obtain the optimum conditions to produce master patterns for use in fabrication of transistors, diodes, and related devices better optical systems were required. The development of these systems was carried out in two phases; first, a high resolution reticle camera was constructed on contract and second, a step-and-repeat camera was designed and assembled in-house. The reticle camera as shown in *Fig. 3* is able to reduce from 18-24 times with a resolution of better than 200 lines per mm over a one inch square area. This camera is used primarily for making patterns that cover areas up to one inch with parts having square corners of approximately .001 inch in width.

The step-and-repeat camera, as shown in *Fig. 4*, was designed to take patterns and locate them in precise positions with maximum resolution. This camera field is limited to an area of .040 by .050 inch. It is so designed that by using different objectives and compensating eye-pieces, a reduction of from 10X to about 200X can be achieved; however, a 20X reduction is normally used.

The step-and-repeat camera consists of two parts: (1) the object end which contains the master pattern, and (2) the image end which contains the final photo-reduced pattern.

The object end contains a light source (incandescent lamp) and interference filter to give monochromatic light (5500 Å); a slot arrangement for positioning the patterns into the approximate optical axis; two toolmaker's micrometer stages, each having an accuracy of .0001 inch in both the X and Y coordinates, for positioning the object pattern on the optical axis; a circular stage with an accuracy of $\frac{1}{10}$ of a degree for rotating the pattern; and a filter system that can be changed so as to exclude the light to which the

[2]Produced in America by Eastman Kodak Co. under the name of spectroscopic plate 649 GH, or high resolution plate.

[3]J. R. Nall and J. W. Lathrop, "The Use of Photolithographic Techniques In Transistor Fabrication," DOFL Report No. TR-608, 1 June 1958.

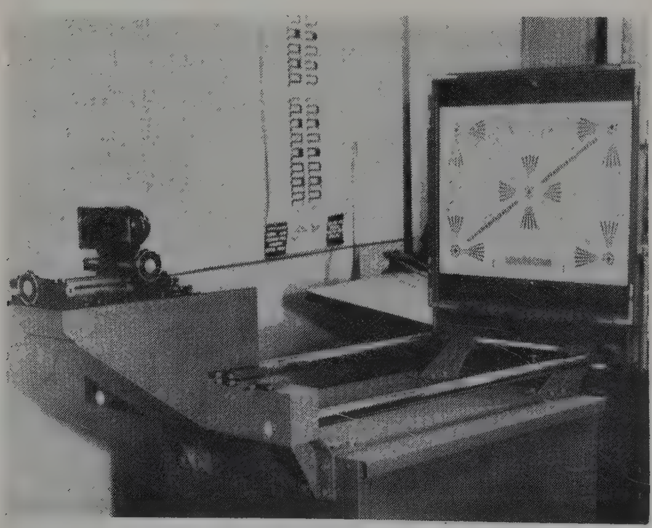

Fig. 3—Reticle camera giving reductions of from 18 to 24 times.

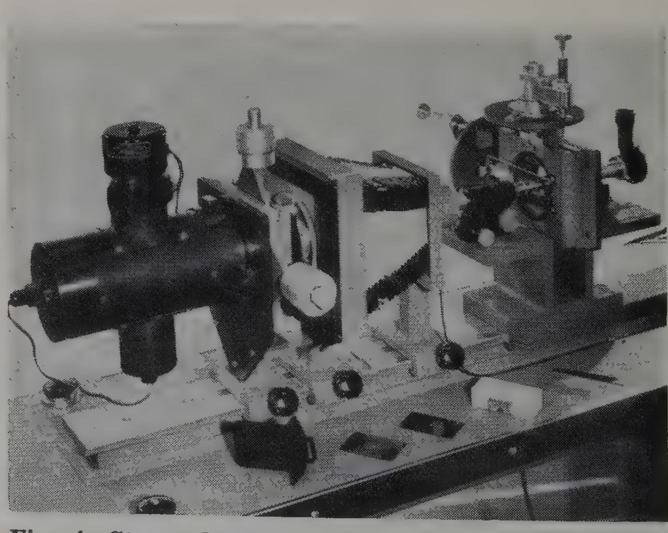

Fig. 4—Step-and-repeat camera developed at DOFL.

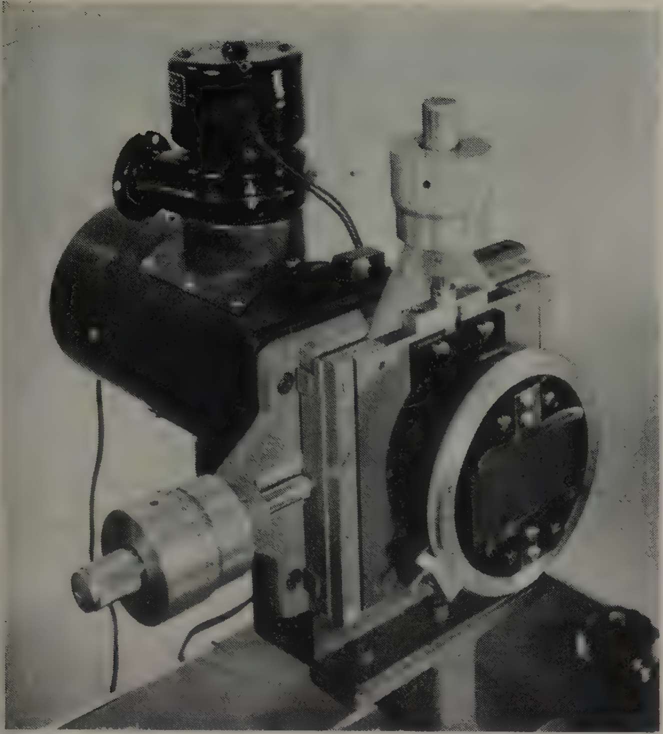

Fig. 5—Light source, filter holder and pattern carriage end of the step and repeat camera.

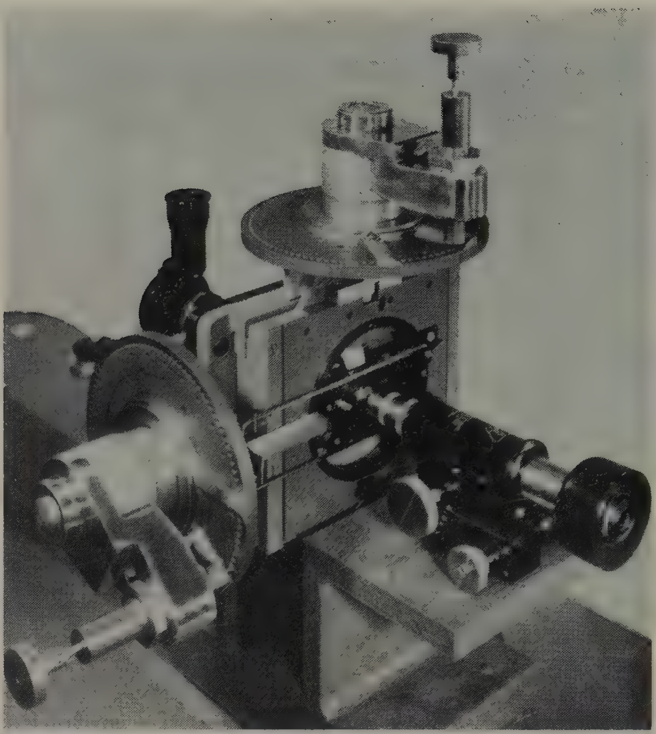

Fig. 6—The image holder end of step and repeat camera showing both indexing heads, microscopes and plate holder.

emulsion is sensitive, and thus focus the pattern directly on the film. *Fig.* 5 shows this end of the camera with a pattern in place for photographing.

The image end of the camera consists of the following: two microscope tubes with 1-micron focusing vernier, a plate holder to rigidly hold the plate in proper optical plane, and two machinist's indexing heads that can be set at .00025 inch spacing $\pm$.0001 inch in both X and Y directions. One microscope is used as the objective of the optical system, the other to assure that the first microscope is focused on the emulsion of the film and to locate the center of dissimilar patterns. *Fig.* 6 shows the system from the operating end. *Fig.* 7 shows a closeup of the plate holder. There are three pins for positioning the plate, and spring pressure to keep it in contact with a milled surface that is parallel to the system. The complete unit is mounted on a double shock-mounted system to eliminate vibration. Patterns as small as 2.5 x 7.5 microns with sharp edges have been produced with this camera.

Preparation of Graphic Art Original

In the early stages of the project, standard drafting techniques were used for making the original prints. In this case, the drawing was made at 100X size with the sharpest and cleanest edge possible. However, it was found to be exceedingly difficult for a draftsman to draw lines on paper that are absolutely straight. The fibers of the paper and the flow of inks would invariably change the dimension. It was found that the best method for making master drawings was to use a hand-operated precision drafting system such as the coordinatograph. With careful operation, lines can be scribed on coated glass to an accuracy of better than .0005 inch. *Fig.* 8 shows a photomicrograph of three types of originals; a) standard drafting technique using ink and ruling pen; b) coated plastic material such as zipatone or similar products cut with a knife; this method gives a sharp edge but it is difficult to cut straight lines; c) coated glass cut on a precision drafting machine, the lines are straight and the areas more precise because the knife holders are contained in fixed planes.

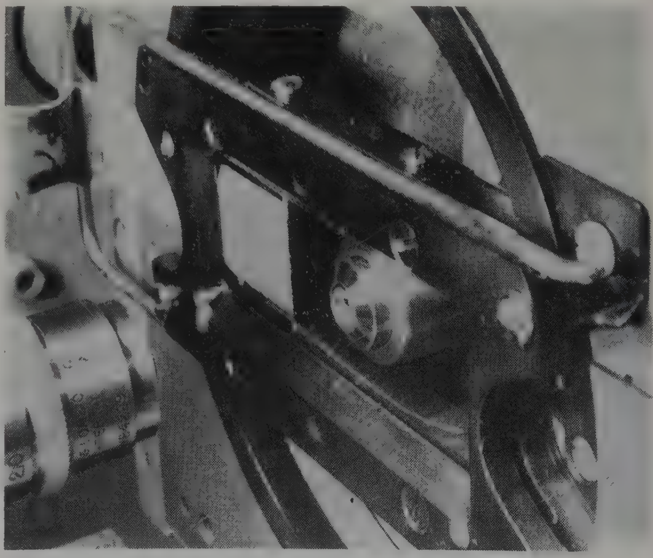

Fig. 7—Close-up of plate holder.

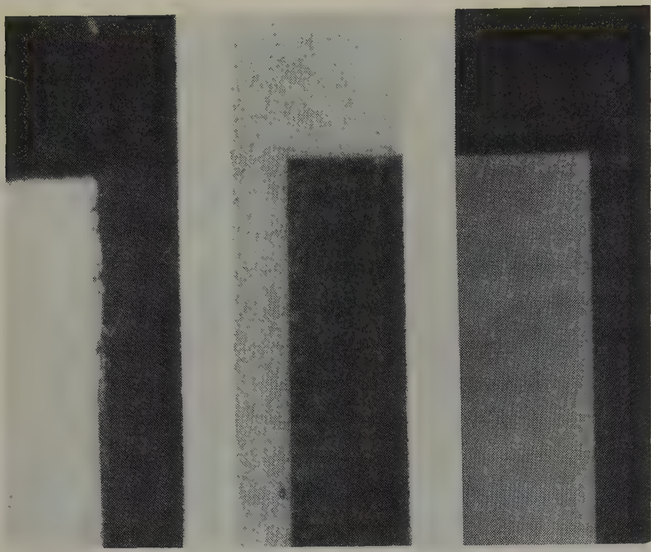

Fig. 8—Comparison of methods making original drawings magnified 22X; (a) Standard drafting methods, (b) Coated plastic material cut with knife, (c) Coated glass cut on precision drafting machine.

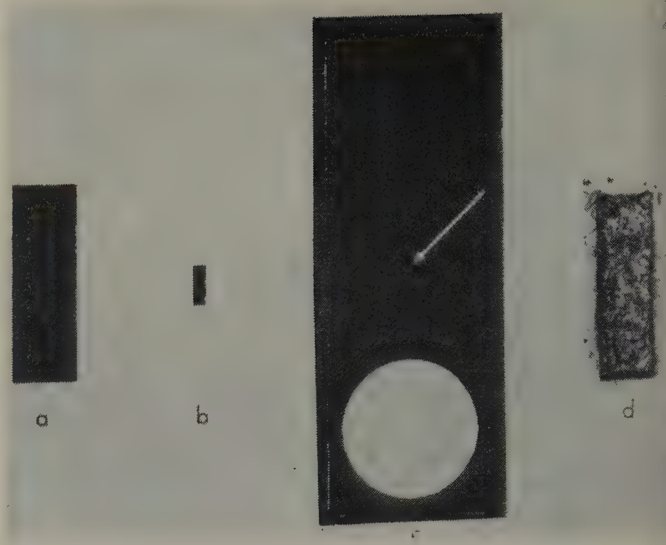

Fig. 9—Steps in making a pattern; (a) the original bar (actual size) (b) reduced 5X; (c) reduced 20X (contact print of master slide); (d) bar after transfer and alloying to germanium, magnified 95X.

Preparation of Master Negatives

The drawings are usually reduced in the minimum number of steps. The more steps, the greater the loss in resolution. Most of the drawings are made at 100X actual size, reduced 5X on a regular camera with Eastman Spectroscopic plates 649, GH, developed in D-19 for 3 minutes at 68°F, fixed, washed, and dried. The drying is done at room temperature in a covered dish with the emulsion down to lessen dust contamination. They are then reduced to their final size either on the reticle camera or the high resolution step-and-repeat microphotographic camera. *Fig. 9* shows the pattern of a bar used in the fabrication of a transistor, (a) the original bar (actual size); (b) the same bar at 5X reduction; (c) further reduced 20X; and (d) a 95X magnification of the pattern after it was transferred to a wafer of germanium. As one approaches the smaller sizes, it becomes very important to focus accurately and to find the surface of the emulsion. From the work accomplished, patterns of 1 micron seem to be the limit of our microphotographic system. This approaches both the best resolution of the lens system and of the plate material, which has a resolution of 2000 lines per mm. Dust and dirt in the air also become large factors when making these small patterns.

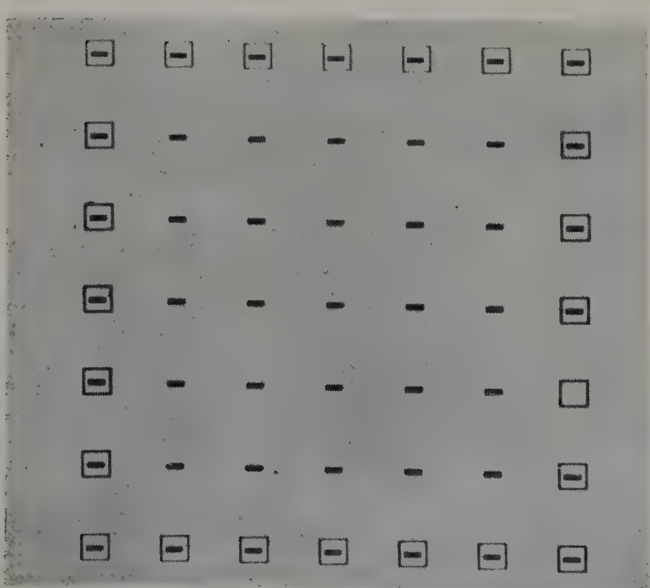

Fig. 10—Two patterns put on a plate with .025 inch spacing at random intervals showing their exact alignment.

The step-and-repeat microphotographic camera is capable of taking different geometric patterns, placing them in X and Y coordinates in steps of .00025 inch, and having them fall into their proper location as shown in *Fig. 10*. When a device is fabricated in multiple, the indexing must be accurately maintained. With the optical system described here, the adjustment of any individual segment of a pattern can be set to .0001 inch. Even assuming the maximum error and the fact that the error is cumulative, a pattern containing ten parallel settings could only be in error by .001 inch. It has been possible to fabricate several devices of either a highly repetitive nature or of an asymmetrical and complicated nature. The patterns most frequently made consisted of a set of one hundred small circles or bars, which were indexed to a set of one hundred annular rings or rectangles.

Applications

Devices

The first use of microphotographs in conjunction with the step-and-repeat camera was in the fabrication of diode matrices. This device consists of an array of one hundred diodes in ten parallel rows as shown in *Fig. 11*. Such a device, with proper etching and interconnection of elements, is very useful in memory or circuitry selection. A circle, one inch in diameter

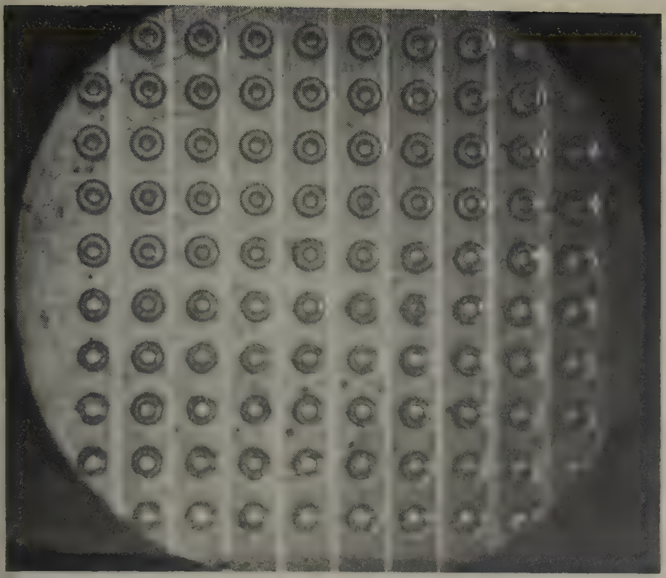

Fig. 11—One hundred diodes on germanium with leads for each 10 diodes. Magnified 12X.

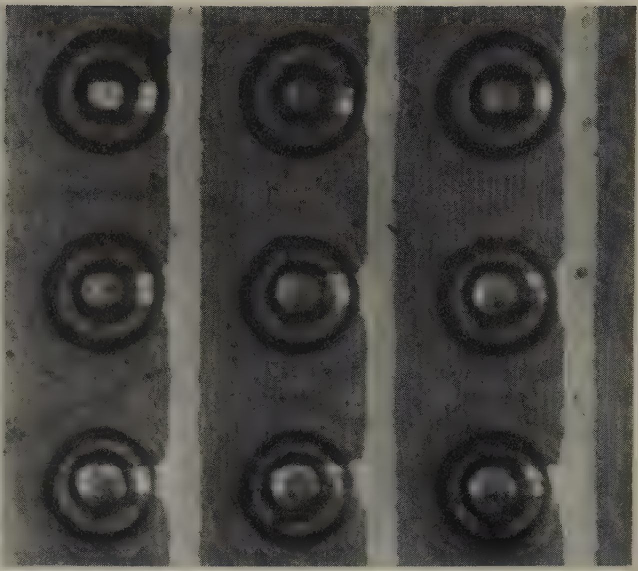

Fig. 12—Diode matrix showing placement of segments. Magnified 45X.

was made with a coordinatograph. This pattern was then reduced 5X, on a one by three inch high resolution glass slide. This pattern was then placed into the object plane shown in *Fig. 5*. Using a red filter the pattern was positioned with respect to the optical axis and focused on the surface of the emulsion in the image plane. After the above adjustment, the plate was exposed to the monochromatic light. The plate was indexed in the proper X and/or Y coordinate and again exposed. This was repeated for each diode in the one hundred diode matrix.

A second pattern, an annular ring, was now required. This pattern was scribed on the coordinatograph and the pattern was formed exactly as for the one hundred circles.

With the completion of the two multiple patterns, the one hundred circles were first exposed onto a one-quarter-inch square piece of diffused germanium which had been coated with Kodak Photosensitive Resist. After development, the square was gold plated such that the gold was deposited only on the areas corresponding to the one hundred circles. The gold was then alloyed into the germanium. The square was then coated with Kodak Photosensitive Lacquer and the annular ring patterns exposed directly over the gold circles. Since this pattern is used as an etch mask, the indexing is quite critical. *Fig. 12* shows a diode matrix where one can see the degree of accuracy of the ring placement over the circles.

Solid Circuitry

The fabrication of a solid-circuit entails the exact placing of a number of circuit elements on a series of plates, all of which have to be in precise register with each other. Because of their asymmetrical shape, the placement of these figures relative to each other is even more critical than for the diode matrix.

In this case, the pattern to be exposed on the spectroscopic plate is placed in the object slot at the front end of the camera. By using the microscope mounted at the other end of the camera the orientation of the pattern may be checked. When it is set in its predetermined position, the red filter is removed and the film is exposed. The second pattern is then placed in the object slot and the plate holder is moved in its X and/or Y plane to the new position. The pattern is then exposed. This procedure is repeated for as many patterns as required.

One can see from *Fig. 13* that because of the length of the figures relative to their width, that without high sensitivity in adjustment of the X and Y, and particularly rotation, great error in the indexing with the subsequent patterns can occur. It is in such critical work as this that the high-sensitivity microphotograph system is essential.

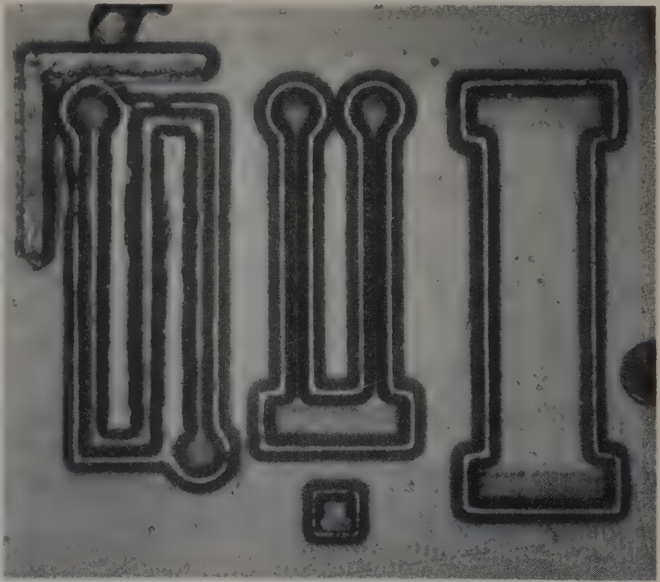

Fig. 13—A multiple number of dissimilar patterns made and reproduced on germanium.

Photo-Mechanical Aids

In the course of transistor fabrication at this installation, much effort has been expended on evaporating aluminum and gold leads for the base and emitter contacts of the transistor. Since this work has been on high-frequency transistors, the base and emitter bars are close together, approximately .001 of an inch. When the aluminum is evaporated, a mechanical mask is used. This mask must have, in addition to the openings corresponding to the leads to the base and emitter contacts, a separation between these openings to prevent the aluminum from shorting the base and emitter. The separation is of the order .0010 to .0015 inch. It is obvious that high resolution is essential in obtaining this mask, for too great a variation could cause the aluminum to the emitter to overshoot the emitter bar and lie directly on the base area. *Fig. 14* illustrates the use of mechanical masks.

Other Applications

In the photoengraving operation, the resulting pattern is less exact than the pattern through which one etches. It is therefore necessary that the masks conform as exactly as possible to the predetermined geometry. With the above-mentioned camera, it has been possible to produce etching patterns of extreme accuracy such that difficulties associated with nonexact patterns has been practically nonexistent.

Summary

Microphotography has been extended into the field of modern electronics where size, weight reduction, reliability, and cost are of prime importance. The basic limitations of using microphotographs for microelectronic applications are the fundamental properties of the emulsions, the lens systems, the wavelength of light used to make the master patterns and the fabrication process. The emulsion is capable of giving a resolution in the order of 0.5 micron and the lens system with a monochromatic light source giving the same. A five micron pattern resolution seems to be a safe figure for practicable use in microphotographic technology.

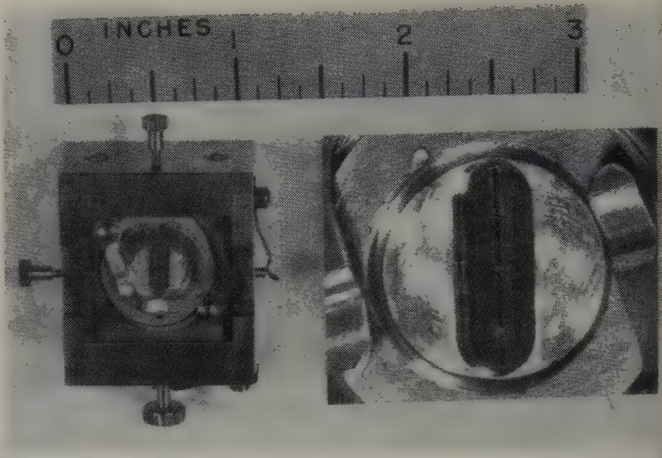

Fig. 14—Jig and an actual mechanical mask made by photographic techniques for evaporating leads on transistors or diodes.

Acknowledgment

We wish to thank David Theodore, Roland Martin, and John Heise for their help and cooperation in the design of the step-and-repeat camera and Severino Sainato and Sandie Hargraves for building the equipment.

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Sept. 16, 1958 to Oct. 21, 1958

Sept. 16, 1958

2,852,448 Crystal Rectifiers And Method—J. J. Dymon, B. E. Bartels. Assignee: Sylvania Electric Products Inc. A method of producing single crystal strontium titanate rectifiers.

2,852,588 Ignition System for an Internal Combustion Engine—F. W. Hartman Jr. Assignee: Holley Carburetor Company. An ignition system that replaces the ordinary circuit breaker with point contact transistors.

2,852,589 Ignition Circuit—K. S. Johnson. Assignee: Holley Carburetor Company. An ignition system for internal combustion engines which replaces the normally used circuit breaker with point-contact transistors.

2,852,625 High Input Impedance Transistor Amplifier—A. Nuut. Assignee: Hycon Mfg. Co. A high input impedance, low noise, temperature stabilized transistor amplifier of simple circuitry.

2,852,648 Photoconductive Cells and Process for Manufacturing Same—S. H. Duffield. Assignee: Eastman Kodak Company. A method for producing small photoconductive cells which includes forming a groove on a glass base block, depositing an electrode material thereon on a masked area, removing the mask and depositing the photoconductive material, and cleaning the glass block outside the groove.

2,852,677 High Frequency Negative Resistance Device—W. Shockley. Assignee: Bell Telephone Labs. A semiconductor

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

negative resistance device modified in such a way as to reduce the impedance of the emitting junction to alternating signals.

2,852,680 Negative Impedance Transistor Oscillator—A. J. Radcliffe, Jr. Assignee: International Telephone & Telegraph Corporation. In a transistor oscillator, a negative impedance converter, with a series tuned circuit to determine the frequency connected across the short-circuit unstable terminals, and a low impedance connected across the open-circuit unstable terminals.

2,852,700 Electric Circuit Including Non-Linear Impedance Elements—R. A. Henle. Assignee: IBM. A circuit for a transistor, said circuit having favorable current gain characteristics but not having any undesirable decrease in back resistance.

2,852,702 Condition Responsive Apparatus —B. H. Pinckaers. Assignee: Minneapolis-Honeywell Regulator Company. A transistorized condition responsive system having an arrangement which charges a capacitor of a relaxation oscillator, and periodically discharges said capacitor to trigger a monostable electric network, thereby controlling a cycling relay.

2,852,722 Eletcric Rectifies Employing Semiconductors—H. R. Noon. Assignee: The British Thomson-Houston Company Limited. A hermetically sealed heat radiating casing for semiconductor rectifiers.

2,852,723 Interplate Contactor For a Rectifier—C. A. Escoffery. Assignee: International Rectifier Corporation. A current collecting contactor for use in a dry plate rectifier assembly, said contactor providing strength for proper assembly without causing excess pressure on the semiconductor surfaces of the plates.

2,852,725 Electrically Maintained Vibratory Oscillator—C. F. Clifford. Assignee: None. A battery operated transistor controlled electromechanical vibratory oscillator.

2,852,730 Power Supply—H. Magnuski. Assignee: Motorola Incorporated. A low power voltage conversion system including a dual transistor square wave oscillator and a highly efficient transformer and coupling arrangement.

2,852,732 Hall Voltage Generators—H. Weiss. Assignee: Siemens-Schuchertwerke Artiengesellschaft. An apparatus that generates a Hall voltage possessing a curved drooping characteristic rather than a straight line characteristic, said apparatus using line or area contact electrodes on the surface of the semiconductor to achieve this result.

2,852,746 Voltage Controlled Transistor Oscillator—P. F. Scheele. Assignee: USA (USAEC) A voltage controlled feedback oscillator capable of generating a frequency variation in its signal of at least ±9% on either side of a center frequency in response to a modulating voltage.

2,852,751 Delay Equalizer Network—W. R. Lundry. Assignee: Bell Telephone Labs. A transistorized all-pass wave transmission network for shifting the phase of a transmitted signal wave without introducing attenuation.

September 23, 1958
2,853,602 Frequency Converter System Having Mixer and Local Oscillator Gain Controlled in Opposite Sense—R. J. Farber. Assignee: Hazeltine Research Incorporated. A system in which the local oscillator excitation increases as the gain-control bias builds up as a result of the reception of received signals of increasing intensity, said system employing a unitary body of semiconductive material which forms a pair of junction transistors.

2,853,603 Dual Channel Transistor Amplifier—E. W. Herold. Assignee: RCA. A circuit utilizing one transistor to amplify both the intermediate frequency and audio frequency signals of a signal receiving system.

2,853,615 Crystal Controlled Transistor Oscillator Systems—R. J. Kircher. Assignee: Hughes Aircraft Company. A crystal-controlled, regenerative-feedback, transistor oscillator, the frequency of which is unaffected by amplitude variations thereof.

2,853,629 Regenerative Transistor Pulse Amplifier—J. H. Felker. Assignee: Bell Telephone Labs. A single-transistor, transformer-coupled, regenerative pulse amplifier using an output transformer in the collector circuit, said arrangement being triggered to a high current state by pulses applied to the emitter, and being reset to the low current state by clock pulses applied to the base.

2,853,631 Signal-Operated Switch—R. L. Wallace. Assignee: Bell Telephone Labs. A transistor operated device that establishes a low impedance connection between an incoming and outgoing conductor upon receipt of said signal or a marking signal preceding it.

2,853,632 Transistor Logical Element—H. J. Gray, Jr. Assignee: Sperry Rand Corp. A logical element which may be directly or capacitively coupled to one or more output points.

2,853,633 Voltage Comparison Transistor Circuit—E. S. McVey. Assignee: None. A compact transistorized circuit for continuously comparing variable and direct current voltages.

2,853,651 Light Responsive System—J. E. Jacobs. Assignee: General Electric Company. An automobile headlight dimming system.

2,853,661 Semiconductor Junction Power Diode and Method of Making Same—C. E. Houle, A. J. Zetes. Assignee: Clevite Corp. A method for hermetically sealing a semiconductor diode by soldering, without adversely affecting the diode characteristics.

2,853,662 Rectifier Construction—John G. Woods. Assignee: International Resistance Company. A dual dry plate diode for use on a printed circuit panel.

2,853,663 Power Transmission—V. K. Kofron, M. D. Levy. Assignee: Vickers, Inc. A blocking layer device comprising a conductive base covered with a layer of selenium on which is deposited a further layer of cadmium sulpho-selenide, and a counter electrode thereon.

September 30, 1958
2,854,318 Method of, and Apparatus for, Producing Semiconductor Materials—T. Rummel. Assignee: Siemens & Halske Artiengesellschaft. A method for producing a wirelike semiconductor body by deposition of material from the gaseous phase.

2,854,358 Treatment of Semiconductor Bodies—B. Schwartz. Assignee: Hughes Aircraft Company. A method of treating of the surface of semiconductor bodies to improve their electrical characteristics, said method comprising polymerization of water hydrolyzable organo—substituted silanes to form a silicone protective film on the semiconductor after it has been etched.

2,854,362 Formation of Junction In Semiconductor—F. A. Brand, H. Jacobs, A Ramsa. Assignee: USA (Dept. of the Army). A method which involves causing an alternating current to surge (in an inert gas atmosphere) through a probe and a block of silicon, there being a small amount of significant impurity material between the probe and the block, separating the point from the block after the material has flowed onto the probe, and then causing the current to periodically arc between them.

2,854,363 Method of Producing Semiconductor Crystals Containing P-N Junctions—K. O. Seiler. Assignee: International Standard Electric Corporation. Formation of a semiconductor having areas of different conductivity type by drawing a crystal from a molten mass of semiconductor and evaporating an impurity of an opposite conductivity type onto the crystal while it is still in the heated state.

2,854,365 Potential Graded Semiconductor and Method of Making the Same—H. F. Matare Assignee: Tung Sol Incorporated. A method of fabricating junction devices to eliminate the requirement for etching, said method involving the forming of the *p-n* junction so that the inversion layer comes to the surface; the transition zone containing said layer is wider, and the potential gradient is less.

2,854,366 Method of Making Fused Junction Semiconductor Devices—A. L. Wannlund, W. P. Waters. Assignee: Hughes Aircraft Company. A method of forming a fuzed junction device having a large area regrown crystal region of controlled thickness and configuration therein.

2,854.516 Electronic Telephone System—A. H. Faulkner, Assignee: General Telephone Laboratories Inc. A system for establishing and maintaining a call between two stations with equipment common to a plurality of stations, which equipment can be used to establish simultaneously calls between other stations of the same group.

2,854,519 Telephone System Including Line Identifying Means—B. A. Harris. Assignee: General Dynamics Corporation. A system with line identifying means which operate automatically through a predetermined number of cyclic line identifying operations.

2,854,580 Transistor Oscillator Frequency Control.—G. A. Vchrin, H. K. Ziegler. Assignee: USA (Dept. of the Army). The frequency of a saturating core transistor oscillator is controlled by means of a *d-c* bias through one of the transformer coils providing initial magnetic flux in the core. The degree of saturation controls the frequency of the square wave oscillator.

2,854,582 Transistor Oscillator Starting Circuit—J. H. Guyton. Assignee: General Motors Corporation. A transistor oscillator starting circuit which is energized from the source of output voltage.

2,854,588 Current Multiplication Transistors—R. W. Landauer. Assignee: IBM. A transistor which has two emitters and two collectors and which achieves high current gain by controlling the reservoir of excess carriers.

2,854,589 Trigger Circuits and Shifting Registers Embodying Trigger Circuits—W. E. Ingham. Assignee: Electric and Musical Industries Limited (England). A binary register unit intended for use as one stage of a shifting register.

2,854,611 Rectifier—R. W. Smith. Assignee: RCA. A broad area semiconductor rectifier, in which the *n*-type material is cadmium selenide or cadmium sulphide, and in which the ohmic electrode comprises at least 50% of indium, gallium, thallium, magnesium, tin, or lead.

2,854,612 Silicon Power Rectifier—E. A. Zaratkiewicz. Assignee: International Telephone & Telegraph Corporation. A power rectifier consisting essentially of a silicon molybdenum bond formed by placing a layer of gold therebetween and heating the bodies in an inert atmosphere in order to form a silicon gold alloy; and to bond the silicon and molybdenum together.

2,854,614 Transistor Circuit Arrangement Having Stabilized Output Voltage—L. H. Light. Assignee: North American Phillips Company. A circuit that yields a stabilized direct voltage output with regard to variations in supply voltage and load resistance.

2,854,615 Circuit Arrangement for Providing a DC output—L. H. Light. Assignee: North American Phillips Company, Inc. In a transistor oscillator a device which prevents the occurrence of oscillations when the direct output voltage exceeds a predetermined value.

2,854,651 Diode Circuits—R. J. Kircher. Assignee: Bell Telephone Laboratories. A series of diode circuits which utilize the Zener effect to achieve a desired output characteristic.

October 7, 1958

2,855,334 Method of Preparing Semiconducting Crystals Having Symmetrical Junctions—K. Lehovec. Assignee: Sprague Electric Company. A method which includes melting a portion of the surface of a germanium crystal having one type of conductivity, adding silicon to the molten portion, and then solidifying the latter into a body having the opposite conductivity.

2,855,335 Method of Purifying Semiconductor Material—K. O. Seiler, S. E. Muller. Assignee: International Standard Electric Co. Purification of semiconductor material by a zone melting process in which the semiconductor body is heated to a given temperature by a heater ring and in which the molten zone is created by induction heating without the use of a crucible.

2,855,461 School To Home Communications System—A. C. Bernstein. Assignee: N. A. Karr, P. H. Seaman. In an intercommunication system, the feature of an overriding priority control which includes a manual switch for establishing the direction of electrical audio signal flow regardless of the position of any other switch in the system.

2,855,468 Transistor Stabilization Circuits—R. D. Lohman. Assignee: Radio Corporation of America. A semiconductor amplifier circuit which provides stable push-pull operation with semiconductor devices having a wide variety of operating characteristics.

2,855,524 Semiconductor Switch—W. Shockley. Assignee: Bell Telephone Laboratories. A switch composed of a *p-n-p-n* monocrystalline silicon body; connections to two zones of said body, the intermediate zones being floating; said body including a high concentration of recombination centers which controls the alpha of the device in accordance with the current density and the predetermined switching level of said density.

2,855,531 Electroluminescent Devices and Systems—F. H. Nicoll. Assignee: Radio Corporation of America. A device which produces electroluminescent images in response to mechanical forces acting on selected areas of the device.

2,855,549 Hall Voltage Generators—F. Kuhat, K. Marz. Assignee: Siemens-Schukertwerke Aktiengesellschaft. A Hall voltage generator designed to compensate for thermovoltages produced when the device is placed in a magnetic field having a high temperature gradient.

2,855,559 Voltage Rectifying Systems—H. C. Goodrich. Assignee: Radio Corporation of America. A system which uses semiconductors to provide controlled voltage rectifying functions through utilization of the bidirectional properties of collector circuit conductivity in a transistor device when the base-emitter circuit is biased in the forward direction.

2,855,568 Semiconductor Oscillation Generators—H. C. Lin. Assignee: Radio Corporation of America. A semiconductor oscillator circuit which can produce an amplitude modulated constant frequency carrier wave, said circuit having a linear modulation characteristic over a broad range of modulating voltage.

October 14, 1958

2,856,320 Method of Making Transistor With Welded Collector—R. E. Swanson. Assignee: International Business Machine Corporation. A method comprising placing a wire of suitable composition to alloy with a semiconductor body and impart thereto a desired conductivity, in contact with said body, and welding the two together with a controlled current by using a capacitor discharge arrangement.

2,856,520 Oscillator Using Point Contact and Junction Transistors For Improved Frequency Stability—H. C. Lin. Assignee: Radio Corporation of America. A transistorized, constant frequency carrier wave oscillator circuit.

2,856,528 Relaxation Oscillators and Electronic Counters—A. E. Brewster. Assignee: International Standard Electric Corporation. A crystal oscillator counter circuit which produces very short duration pulses of approximately 10 microsecond duration, said counter capable of being used as a pulse frequency divider where an accurate time scale is required.

2,856,541 Semiconducting Device—J. E. Jacobs. Assignee: General Electric Company. An X-ray detecting panel comprising stacked layers of X-ray sensitive crystalline semiconductors separated by layers of conducting material in contact therewith, said semiconductor layers thereby being connected in parallel.

2,856,544 Semiconductive Pulse Translator—I. M. Ross. Assignee: Bell Telephone Laboratories. A device having a semiconductor geometry which can provide rapid switching of conductive paths to accommodate signals applied at megacycle rates, said geometry including two zones common to all stepping sections with one contact to said zones and common to said sections.

2,856,553 Electroluminescent Display Device—H. K. Henisch. Assignee: Sylvania Electric Products Inc. A device which displays a dark image against a light background by selectively quenching electroluminescent radiation at selected areas on an energized electroluminescent panel.

2,856,571 Subminiature Semiconductor Instrument and Method and Apparatus for Producing the Same—W. Holzemann. Assignee: Kieler Howaldtswerke Aktiengesellschaft (Germany). A ball shaped semiconductor device imbedded in resin and possessing acceleration resistant, vibration resistant, and temperature resistant properties.

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2,856,681 Method of Fixing Leads to Silicon and Article Resulting Therefrom—J. W. Lacy. Assignee: Texas Instruments Incorporated. A method for attaching lead wires and tabs to silicon blocks in a manner which will not fail over a wide temperature range, said method comprising coating the block with a paste containing silver particles, a vaporizable binder and bismuth as a catalyst, and thereafter heat-treating said block at 525°C to 700°C for 15 to 60 minutes.

2,857,249 Method of Purifying Silicon Tetrachloride—G. A. Wolff. Assignee: U.S.A. (Department of the Army) A method for removing boron traces from silicon tetrachloride to be used in producing transistor grade silicon.

2,857,293 Selenium Rectifiers—E. L. French. Assignee: Westinghouse Brake and Signal Co. Ltd. The formation of a nongenetic layer by applying to a selenium layer on a base plate a saturated solution of polyvinyl chloride to which a primary amine has been added.

2,857,462 Transistor Amplifier Circuit—H. C. Lin. Assignee: Radio Corporation of America. A transistor signal amplifier for electromechanical transducers having a capacitive internal impedance which provides equalization for the output characteristics of the transducers, and low distortion and noise for the amplifier circuit.

2,857,464 Carrier Operation of Multistation Telephone Lines—F. J. Singer. Assignee: Bell Telephone Laboratories. A system whereby a physical party telephone line can be rendered simultaneously usable by all subscribers on a complete privacy basis.

2,857,470 Transistor Line Identifier—A. H. Faulkner. Assignee: General Telephone Laboratories. A line detection and identification system which originates its thousands and hundreds indications at the same transistors at which the tens and unit indications are originated.

SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Forward Voltage Drop and Power Loss in Silicon Rectifiers	App and Ind AIEE July 1960	The instantaneous forward voltage drop of silicon diodes of different sizes and processes is investigated over four magnitudes of current density.	W. Luft
A Transistorized D-C Voltage Regulator for Direct Replacement of Carbon-Pile Regulators	App and Ind AIEE July 1960	Tests have proved that this regulator not only possesses the advantages inherent in a static electric device but that all practical system requirements are adequately met.	P. D. Corey W. O. Hansen
The Silicon Diode in Audio Equipment	Audio July 1960	Discussion of silicon diodes as power rectifiers and bias regulators.	L. B. Dalzell
Impurity Redistribution and Junction Formation in Silicon by Thermal Oxidation	Bell Syst Tech Jl July 1960	An analysis of phenomena observed predicts that single or two junction material can be obtained by oxidation of the surface of a compensated silicon crystal.	M. Atalla E. Tannenbaum
Infrared Radar, Surveillance and Communications	Br Comm & Elecnes July 1960	Consideration is given to the techniques of passive microwave radiometry and far infrared surveillance.	C. M. Cade
Etch Pits and Dislocations in Cadmium Sulphide Crystals	Br Jl Appd Phys July 1960	A technique is described for producing etch pits on various growth faces of cadmium sulphide crystals.	J. Woods
Choosing Induction Regulation for Rectifier Control	Control Engg July 1960	Explanation of a method of calculating optimum range for tube and semiconductor rectifiers to insure most efficient use of regulating capacity.	P. N. Wise
High Frequency Transistors and Their Figures of Merit	Elecl Des News July 1960	Definitions, and a brief summary of the salient points relative to the figures and merits of high frequency transistors.	C. D. Simmons
Nuclear Radiation Damage to Transistors	Elecl Mfg July 1960	A study of radiation damage to transistors in an environment equivalent to that of a nuclear explosion.	Staff Report
Parasitic Oscillations in I.F. Stages and Frequency Changers of A.M. Receivers	Elecn Applcns (Philips-Neth) Vol 20 No 2 1959-60	Cause of oscillation in transistor circuits is explained. Design which render stages completely stable is indicated.	H. H. van Abbe
Transient Behaviour and Fundamental Transistor Parameters	Elecn Applcns (Philips-Neth) Vol 20 No 2 1959-60	Detailed analysis of the transient behavior of alloy junction transistors, both when switching on and switching off.	C. le Can
Silicon Controlled Rectifiers Automatically Sets Initial Multivibrator State	Elecnc Design July 6 1960	Combined with proper timing circuitry a silicon controlled rectifier sets the initial multivibrator state and then allows the multivibrator to function in a normal, balanced manner.	R. Mammano
Selecting Transistors and Diodes for Logic Applications	Elecnc Design July 6 1960	Several transistor logic modes (DCTL, RLT, RCTL, DL and CML) are described, and the criteria for diode and transistor selection are outlined.	A. Corbin
Generate Variable Delays with DC Controlled Flip-Flop	Elecnc Design July 20 1960	Remote-controlled delay generators with no crosstalk or loading problems.	C. Askansas C. Uretsky
A Sensitive Transistor Recording-Pen Amplifier	Elecnc Engg (Br) July 1960	High sensitivity results if a recording-pen movement is connected in a bridge circuit in which two arms of the bridge consist of transistor elements.	K. Beauchamp
Complementary Transistor Circuits	Elecnc Engg (Br) July 1960	A number of circuits useful for pulse and digital applications are described.	F. Oakes C. Thompson
An A.C. Transistor Millivoltmeter with a High Input Impedance	Elecnc Engg (Br) July 1960	Input impedance is 1 to 6 megohms; frequency range is 1 C/s to 200 kc/s; full scale sensitivity of 10 mv with an accuracy of 2% full scale deflection.	R. R. Vierhout
A Single Transistor Radiation Survey Meter	Elecnc Engg (Br) July 1960	Employs a single transistor which provides the high voltage necessary for the G.M. counter; at the same time integrates the pulses to be measured.	B. Birnbaum
A Negative Capacitance Preamplifier for Electrophysiological Use	Elecnc Engg (Br) July 1960	A positive feedback circuit giving negative input capacitance is analyzed. The limitations of frequency response are discussed.	B. M. Johnstone I. D. Pugsley
Delayed Output Sawtooth Generator	Elecnc Equip Engg July 1960	Four-transistor circuit uses monostable multivibrator, bootstrap generator, diode comparator, and pulse amplifiers to obtain output sawtooth delayed in time proportional to d-c voltage level.	I. Albert
A Useful Transistor Model	Elecnc Equip Engg July 1960	Simplified transistor equivalent circuit is adapted to a model that can be fitted directly into schematic diagrams.	R. B. Hurley
A Solid State Circuit Breaker	Elecnc Industries July 1960	Description of a solid state circuit breaker based on the bistable flip-flop.	J. V. Hanson
Survey of Thermistor Characteristics	Electronics July 1 1960	Categorization of thermistors into two basic types and several categories under each type. A convenient method of looking up thermistor characteristics and applications.	J. Van Dover N. F. Bechtold
Transistorized Data Amplifier Has High Gain-Stability	Electronics July 1 1960	Circuit refinements and careful design give a data amplifier with high gain stability, linearity, and low-output impedance.	F. Offner
Portable Radio Uses Drift-Field Transistors	Electronics July 8 1960	Nine transistor AM/FM portable uses drift-field transistors in tuner and *i-f* amplifier.	R. A. Santilli H. Thanos
Static Inverter Delivers Regulated 3-Phase Power	Electronics July 8 1960	Use of silicon controlled rectifier results in high overload capacity, and fewer components. Magnetic amplifier is used as regulating reactive element.	M. L. Lilienstein
Hall-Effect Multipliers	Electronics July 15 1960	Description of a Hall generator which when combined with a transistor amplifier results in useful computing circuit elements.	W. A. Scanga A. R. Hilbinger C. M. Barrack
Solid-State Pulse Modulator	Electronics July 22 1960	Modulator uses silicon gated diodes to pulse a beacon transmitter. Modulator functioning and design are described.	W. H. Lob
Design of Static Relays for Signaling and Control	Electronics July 22 1960	Static relays provide an alternative to electromechanical devices; have superior characteristics for some critical applications.	R. Langfelder
Signal-Seeking Auto Radio Uses Semiconductor Tuning	Electronics July 22 1960	Replaces conventional tuning capacitors with silicon semiconductors. Remote and nonmechanical signal-seeking are advantages obtained.	J. G. Hammerslag

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Measurement of the Equivalent Circuit Parameters of Tunnel Diodes	G-R Experimenter July-Aug 1960	These problems together with suggestions for their solution are discussed in this article.	No Author
Understanding Solar Measurements	Hoffman Span May-June 1960	The devices under consideration are silicon solar cells applied as converters of sun energy into electric power.	H. Rauschenbach
Design Consideration of Photovoltaic Solar Energy Converters for Space Vehicles	Hoffman Span July & Aug 1960	The design objective is to safely meet the power demand of the vehicle, and its instrumentation and communication systems.	M. Wolf
The Complementary Silicon Controlled Rectifier	Hoffman Span July & Aug 1960	For each silicon controller rectifier requiring a positive gate current, a complementary counterpart is offered requiring a negative gate current.	E. F. Koshinz
Epitaxial Vapor Growth of Ge Single Crystals in a Closed Cycle Process	IBM Jl Res & Dev July 1960	The Ge-I_2 disproportionation will deposit Ge epitaxially upon Ge seeds at a typical rate of 10/u/hr, at a typical temperature of 400°C.	J. C. Marinace
Electrical Properties of Vapor Grown Junctions	IBM Jl Res & Dev July 1960	A method of fabricating *p-n* junctions devices by a closed-cycle iodide vapor-growth process is described.	M. J. O'Rourke J. C. Marinace R. L. Anderson W. H. White
A Vapor Grown Variable Capacitance Diode	IBM Jl Res & Dev July 1960	These diodes are produced by a vapor-growth process in which the doping is switched from *n*-type to *p*-type during growth.	R. L. Anderson M. J. O'Rourke
Radiotracer Studies of the Incorporation of Iodine into Vapor Grown Ge	IBM Jl Res & Dev July 1960	Measurements of the incorporation of iodine into single crystals of Ge grown by the disproportionation of GeI_2 have been made using L^{131} as a radioactive trace.	W. E .Baker D. M. J. Compton
Incorporation of As into Vapor Grown Ge	IBM Jl Res & Dev July 1960	The incorporation of arsenic into single crystal germanium grown by the disproportionation of GeI_2 was studied using As^{76} as a radioactive tracer, using measurements of the Hall effect.	W. E. Baker D. M. J. Compton
Tunnel Diodes by Vapor Growth of Ge on Ge and on GeAs	IBM Jl Res & Dev July 1960	Tunnel diodes were prepared from these junctions; preliminary result are discussed and compared with similar studies on alloy junctions.	J. C. Marinace
Germanium-Gallium Arsenide Heterojunctions	IBM Jl Res & Dev July 1960	The purpose of this communication is to summarize some tentative results obtained in a study of the electrical characteristics of these junctions.	R. L. Anderson
Incorporation of Au into Vapor Grown Ge	IBM Jl Res & Dev July 1960	Reported here is a study of the incorporation of gold, chosen as a representative nonhydrogenic impurity, into vapor grown germanium.	W. E. Baker D. M. J. Compton
Impurity Introduction During Expitaxial Growth of Silicon	IBM Jl Res & Dev July 1960	This work has been extended in order to investigate the possibilities of codeposition of desired impurities and silicon.	R. Glang B. W. Kippenhan
Dislocation Content in Epitaxially Vapor Grown Ge Crystals	IBM Jl Res & Dev July 1960	The preliminary results of a study of the dislocation content of such crystals is reported.	H. S. Ingham Jr. P. J. McDade
Photo-Sensitive Resistor in an Overload-Preventing Arrangement	IRE Tr Audio July 1960	The CdS cell can be readily applied as a volume-control device for an amplifier by combining it with a small lamp.	J. R. De Miranda
Transistorized Deflection Circuits for 110° Picture Tubes	IRE Tr B & TV Rec July 1960	The problem of applying transistors and diodes to the deflection circuits of TV receivers was investigated originally with 21" 90° picture tubes, and more recently with 23" 110° tubes.	R. L. Sager G. Strachanow G. W. Fyler
Transistorized FM and TV Limiter Design and Performance	IRE Tr B & TV Rec July 1960	This paper discusses recent experiments which demonstrate the feasibility of using transistor limiters at 4.5 and 10.7 mc.	C. R. Gray T. C. Lawson
A New TV Remote Control Package, Transistorized for Compactness	IRE Tr B & TV Rec July 1960	Most significant design problems are noise immunity, power detection of selected frequencies, variation in transistor characteristics, temperature, and power consumption.	R. Wolff M. Marks
Unique Design Considerations for Transistorized TV	IRE Tr B & TV Rec July 1960	Design consideration involved in the development of a 19" 114° transistorized portable TV receiver are given.	L. Mattingly A. Massman
A Transistor TV Tuner with a 4.5 db Noise Figure	IRE Tr B & TV Rec July 1960	An experimental MADT transistor designed for TV RF amplification and a prototype tuner designed to use this transistor.	C. D. Summons J. Specialny
Design of an AM/FM Transistorized Receiver	IRE Tr B & TV Rec July 1960	Design consideration include FM front end unit, self-oscillating mixer, *i-f* amplifier, FM detector, AM detector, *a-g-c*, and AF section.	H. Von Abbe
Transient Operation of Transistor with Inductive Load	IRE Tr Elecnc Dev July 1960	A transistor operating with an inductive load may develop a collector-emitter short circuit when the transistor is suddenly turned off.	H. C. Lin A. R. Hlavacek B. H. White
Design Consideration for a Germanium *p-n-p-n* Switching Device with Three Contacts and a "Sandwich"	IRE Tr Elecnc Dev July 1960	The current I_{off} through a germanium *p-n-p-n* switch in the OFF state is described as a simple junction of the control current I_t in its third contact.	G. Wertwijn
A Portable, Self-Contained Electronic Cardiotachometer for the Medical Research Profession	IRE Tr Med Elecncs July 1960	This paper describes the SAVE operation and one of their projects, a portable (3-ounce) self-contained cumulative heartbeat recorder.	L. J. Ryan
Explorer Satellite Electronics	IRE Tr Mil Elecncs April-July 1960	Methods used to obtain reliability in the transducing and communications system are described.	W. K. Victor H. L. Richter J. P. Eyraud
Power Sources Designed for Space	IRE Tr Mil Elecncs April-July 1960	Conversion systems employing chemical, solar, and nuclear energies are described, and their prospects for further improvement discussed.	W. Shorr D. Linden A. F. Daniel
Problems Concerning the Thermal Design of Explorer Satellites	IRE Tr Mil Elecncs April-July 1960	Some examples of the preliminary evaluation of the thermal experiment of explorer VII are given.	G. B. Heller
Diagrams Representing States of Operation of a General Thermocouple	Jl Appl Phys July 1960	The state of operation of a thermocouple depends on three independent parameters: the current I and the temperatures T_1 or T_2 of the junctions.	A. Boerdijk
Time Discrimination in Solid-State Infrared Quantum Counters	Jl Appl Phys July 1960	A discussion of various considerations in the practical realization of the infrared solid state quantum counter recently proposed by Bloembergen.	J. V. Jelley

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ropagation Mechanism of Ger-anium Dendrites	Jl Appl Phys July 1960	The role of the twin planes in the rapid dendritic propagation of germanium crystals is examined on the bias of corner nucleation.	D. R. Hamilton R. G. Seidensticker
niform Silicon p-n Junction. I. road Area Breakdown	Jl Appl Phys July 1960	Charge multiplication as a function of reverse bias has been studied in a number of uniform silicon p-n junctions (junctions free from defects which promote local avalanche breakdown sites).	A. G. Chynoweth
niform Silicon p-n Junctions. II. onization Rates for Electrons	Jl Appl Phys July 1960	Small area silicon p-n junctions have been made which are free from exposed edges and dislocations passing through the space charge region.	R. Baldorf A. Chynoweth G. C. Dacey P. W. Fay
rowth of Atomically Flat Sur-aces on Germanium Dendrites	Jl Appl Phys July 1960	This note presents a theory of the formation of extended flat surfaces on germanium dendrites.	R. L. Longini A. I. Bennett W. J. Smith
arametric Diode Figure of Merit nd Optimization	Jl Appl Phys July 1960	The noise figure and gain expression for the diode parametric amplifiers are presented and discussed which include the effects of diode losses.	K. E. Mortenson
amma Irradiation of Silicon. I. evels in n-type Material Con-aining Oxygen	Jl Appl Phys July 1960	The resistivity and Hall coefficient of n-type silicon containing oxygen have been measured as a function of temperature before and after a number of successive irradiations in Co^{60} gamma ray source.	E. Sonder L. C. Templeton
n Analogue-Digital Converter vith Long Life	Jl Br IRE July 1960	A transistorized instrument has been developed for converting small voltages representing a measured parameter into a digital representation of the parameter.	R. L. G. Gilbert
Characteristics of Germanium p-n Junction with Irregular Structure	Jl Phys Soc Japan July 1960	Particular attention is paid to the electron current component which flows through the minute area of the m-n junction existing at the irregular part of the p-n junction.	M. Tomono
Note on the Field Dependence of he Mobility in Semiconductors	Jl Phys Soc Japan July 1960	By assuming that the mobility can be expanded in powers of the field strength γ is calculated for non-polar and polar semiconductors.	M. Hattori H. Sato
Measurement of Magnetostriction Within the Temperature Range −196° to 400° C	Jl Scient Inst (Br) July 1960	Resistance strain gauges are employed and the performance of a number of gauges has been investigated at these temperatures.	R. R. Birss E. W. Lee
The Theory and Practice of Vac-uum Melting	Metal Rev Inst of Metals (Br) 1960 Vol 5 No 17	Complete and exhaustive state of the art presentation includes diagrams of vacuum furnaces.	O. Winkler
A Transistorized Radiation Moni-tor	Philips Tech Rev June 1960	As a measuring instrument the circuit employed must be designed so that the readings are insensitive to the transistor characteristics.	M. van Tol F. Bregman
Segregation and Distribution of Impurities in the Preparation of Germanium and Silicon	Philips Tech Rev June 1960	Germanium is processed in a graphite boat, successive molten zones traversing the charge at short distance apart. Silicon is purified by passing one zone through a vertical charge clamped at each end, the zone held together by its own surface tension.	J. Goorissen
An Automatic Dew Point Hy-grometer Using Peltier Cooling	Philips Tech Rev June 1960	The cooling required for this purpose can be obtained by utilizing the Peltier effect with a combination of certain semiconductors.	P. Gerthsen J. A. A. Gelsing M. van Tol
Dislocation Nets in Bismuth and Antimony Tellurides	Philosophical Mag July 1960	The electron microscopic examination of thin foils of bismuth and antimony telluride reveals the presence of extended dislocation patterns.	P. Delavignette S. Amelinckx
Surface Dependent 1/f Noise in Germanium	Physical Review July 1 1960	The surface characteristics of 1/f noise has been investigated by using field effect techniques on 100 micron thick single crystal germanium filaments.	A. U. Mac Rae H. Levinstein
Electrical and Optical Investiga-tion of Absorption Centers in Rutile Single Crystals	Physical Review July 15 1960	Absorption centers can be produced by thermal quenching or optical irradiation at the edge of the characteristic absorption region.	K. G. Srivastava
Weak-Field Magnetoresistance in p-type Lead Telluride at Room Temperature and 77° K	Physical Review July 15 1960	The weak-field magnetoresistance of six single crystals of p-type PbTe was measured at room temperature and at 77° K.	R. S. Allgaier
Comparison of Structures of Sur-faces Prepared in High Vacuum by Cleaving and by Ion Bombard-ment and Annealing	Physical Review July 15 1960	In the case of this crystal it is concluded that both methods produce essentially clean surfaces with the same atomic arrangements.	D. Haneman
Adsorption and Bonding Properties of Cleavage Surfaces of Bismuth Telluride	Physical Review July 15 1960	No measurable adsorption of oxygen, nitrogen, or carbon monoxide was found for any of the clean surfaces produced.	D. Haneman
Excitons and the Absorption Edge of Cadmium Sulfide	Physical Review July 15 1960	Measurements of the absorption coefficient between 10 and 300 cm have been made with crystals of polarized light.	D. G. Thomas J. J. Hopfield M. Power
Trapping and Diffusion in the Sur-face Region of Cadmium Sulfide	Physical Review July 15 1960	Hole-electron pairs generated at the surface diffuse into the crystal until the hole is trapped.	J. J. Brophy
Infrared Absorption and Valence Band in Indium Antimonide	Physical Review July 15 1960	Infrared absorption is studied at near liquid helium temperature for n- and p-type degenerate samples of various carrier concentrations.	G. W. Gobeli H. Y. Fan
Photemission from Si Induced by an Internal Electric Field	Physical Review July 15 1960	External photoelectric emission from silicon has been observed from a back biased p-n junction which had received a cesium surface treatment.	R. E. Simon W. E. Spicer
Current-Carrier Transport and Photo-conductivity in Semicon-ductors with Trapping	Physical Review July 15 1960	Fundamental differential equations are derived under the unrestricted approximation of electrical neutrality that admits trapping.	W. Van Roosbroeck
Controlled Rectifiers Using Tran-sistors	Proc Inst EE (Br) Part B July 1960	The stability conditions for the open and closed states of a complementary switch are investigated graphically.	E. E. Ward
Transistors for Regulation of Air-craft Power Systems	Proc Inst EE (Br) Part B July 1960	A complete 2-generator d-c system has been built, and has been found to give substantial improvements in performance over a conventional system.	K. Bacon
Low Noise Parametric Amplifier	Proc IRE July 1960	The theory of the parametric amplifier has been reformulated to permit the prediction of noise temperature and pump power in terms of the physical parameters of the nonlinear element and circuit.	R. C. Knechtli R. D. Weglen

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Theory of Single Resonance Parametric Amplifiers	Proc IRE July 1960	Determination of the stability criteria and power gains associated with a nonlinear capacitance that is incorporated in a network producing a resonance at the idler frequency but not at the signal frequency.	S. Fisher
Limitations and Possibilities For Improvement of Photovoltaic Solar Energy Converters	Proc IRE July 1960	Seven factors limiting the performance of photovoltaic solar energy converters are listed and explained.	M. Wolf
Unidirectional Paramagnetic Amplifier Design	Proc IRE July 1960	The radio frequency parameters and the quantum mechanical parameters entering into the design of paramagnetic quantum mechanical amplifiers are described and discussed.	M. Strandberg
Skin Effect in Semiconductors	Proc IRE July 1960	This paper deals with the theory of skin effects in semiconductor materials including the effect of displacement currents.	A. H. Frei M. J. O. Strutt
Miniature Electronic Instruments for Medical Research	Res Appd in Ind (Br) July 1960	A transistorized F.M. transmitter useful for medical research is described.	D. W. Baker D. L. Franklin R. M. Ellis
Transistorized TV and FM Tuners	Semiconductor Prods July 1960	Design considerations for VHF front ends using MADT and mesa transistors as r-f amplifiers, mixers and oscillators.	K. Wittig
Application of Transistors to Video Equipment, Part III	Semiconductor Prods July 1960	Final article in series discusses the image orthicon camera.	K. Hiwatashi et al
Temperature Dependence of Carrier Densities, Mobilities, Diffusion Constants and Conductivities in Germanium and Silicon	Semiconductor Prods July 1960	Graphs are provided showing the above-mentioned properties for impurity concentrations usually encountered in semiconductor devices, and over the temperature range usually encountered in device operation.	W. W. Gartner
Transistor-Capacitor Shift Register	Semiconductor Prods July 1960	A shift register is described in which capacitors are used as the information storage elements.	R. W. Hofheimer
Electrical Conductivity of High Vanadium Phosphate Glass	Sol State Elecncs July 1960	The electrical conductivity of high vanadium phosphate glass is studied as a function of its composition.	M. Munakata
Calculation of Concentration Profiles and Surface Conductance Measurements of Diffused Layers	Sol State Elecncs July 1960	A method for obtaining the sheet-conductance profile of a diffused layer by ohmic contacts to the layer is suggested.	M. F. Lamorte
Germanium *p-n* Junction-Tunnel-Junction Combination Devices	Sol State Elecncs July 1960	Semiconductor devices employing both normal *p-n* junctions and tunnel junctions (designated *p,-n*) can utilize properties of a tunnel junction to impart new or improved characteristics to the overall structure.	I. A. Lesh H. A. Jensen
The Regrown-Diffused Transistor	Sol State Elecncs July 1960	A new process for producing high frequency *n-p-n* silicon transistors is described.	C. H. L. Goodman
Variation with Temperature of the Distribution Coefficient of Indium in Germanium	Sol State Elecncs July 1960	A relationship is derived giving the solid solubility of the emitter material (indium) in the base crystal (germanium) in terms of the slope of a plot of reciprocal current gain vs emitter current.	M. A. Lee
Cross-Sectional Resistivity Variations in Germanium Single Crystals	Sol State Elecncs July 1960	The dependence of these variations upon crystal orientation as well as upon the shape of the solid-liquid interface during crystal growth has been investigated.	J. A. M. Dikhoff
The Operation of Junction Transistors at High Current and in Saturation	Sol State Elecncs July 1960	The lumped-model characterization for junction transistors has been extended to current ranges where the transistor operation may no longer be considered linear.	C. A. Mead
Semiconductor Type and Local Doping Determined through the Use of Infrared Radiation	Sol State Elecncs July 1960	Infrared techniques for determining semiconductor types and local doping are discussed, and examples of measurements as applied to inhomogeneities in germanium are given.	N. J. Harrick
The Effect of Mechanical Treatment of the Surface on the Fine Structure of Photoconductivity Response in Cadmium Sulfide Crystals	Sov Phys Solid State June 1960	Even a gentle surface treatment produces self-reversal and false photocurrent maxima; the false maximum at longer wavelengths is broadened and displaced on increase of the severity of the surface treatment.	E. F. Gross B. V. Novikov
Influence of the State of the Surface on the Breakdown Voltage of Alloy Type Silicon Diodes	Sov Phys Solid State June 1960	A change in breakdown voltage occurs when the surface states of specimens with *p-n*-transitions are cyclically reproduced. In the present paper, the results of some tests along this line with silicon diodes are described.	Y. I. Alferov E. V. Silina
"Breakdown" of Alloy-Type Silicon Diodes in the Transmission Direction	Sov Phys Solid State June 1960	A "breakdown" effect has been observed in the transmission direction in alloy-type silicon diodes at room temperatures.	Y. I. Alferov E. A. Yarv
Magnetothermal Nernst-Ettingshausen Effects in Indium Arsenide	Sov Phys Solid State June 1960	The results of measurement of these effects in *n*-type InAs, with room-temperature electron density $n=7.10^{16}$ to 9.10^{19} cm^{-3}, are given.	O. V. Emil'aganenko N. V. Zotova D. N. Nasledov
The Energy Spectrum of Holes in Bi_2Te_3	Sov Phys Solid State June 1960	The present paper deals with the direct calculation of the whole-energy spectrum, taking the valence bonds into account.	E. K. Kudinov
Temperature Dependence of the Low-Frequency Fluctuations of Conductivity in Germanium	Sov Phys Solid State June 1960	Th authors have studied the temperature dependence of this effect in element semiconductors.	M. I. Kornfel'd D. N. Mirlin
A New Semiconducting Compound in the In-Sb-Te System	Sov Phys Solid State June 1960	As a result of zone recrystallization of an InSb-In_2Te_3 alloy of the indium-antimony-tellurium system, a new phase of composition InSb-InTe, was obtained.	N. A. Gorgunova S. I. Radaustan G. A. Kiosse
Current Voltage Characteristics of the Autoelectron Current from Semiconductors	Sov Phys Solid State June 1960	Data is presented which contrasts with other published data concerning voltage current characteristics of the auto-electron current from two semiconductors, tungsten carbide and germanium.	Yu. V. Zubenko A. I. Klimiv L. I. Sokol'skaya
Thermal Expansion of Silicon at Low Temperatures	Sov Phys Solid State June 1960	The behavior of two samples consisting of single crystals of silicon which were pure enough to meet the requirements of semiconductor techniques were studied.	S. I. Novikova P. G. Strelkow
The Influence of Deformation on the Electrical Properties of *p*-Germanium and Silicon	Sov Phys Solid State June 1960	The authors have calculated the changes in conductivity, the Hall coefficient, and the magnetoresistance for uniform deformation.	G. E. Pikus G. L. Bir

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Investigation of the Thermoelectric Properties of $CoSb_3$ with Sn, Te and Ni Impurities	Sov Phys Solid State June 1960	Investigation of the influence of electrically active impurities upon the thermoelectric properties of the compound $CoSb_3$.	B. N. Zobrina L. D. Dudkin
A Power Directional Relay Using the Hall Effect	Sov Phys Solid State June 1960	The relay consists of phase-shifting elements R, C, and L, corresponding to transformers, two Hall *emf* pickups, and a polarized relay.	U. N. Bogomolov U. K. Siretko
The Depolarization Charge of Barium Titanate and its Connection with the Piezoelectric Effect	Sov Phys Solid State June 1960	On the basis of the discharge current, the dependence of the residual polarization upon the intensity of the polarizing field and upon the duration of the polarization has been computed.	F. I. Kolomitsev I. A. Iyhak
A New Intermetallic Semiconductor Compound	Sov Phys Solid State June 1960	During the chemical interaction of sodium and antimony, an intermetallic compound NaSb is formed. This compound crystallizes in a monoclinic system, and contains eight molecules per unit cell.	Ya. A. Ugai T. N. Vigutova
The Influence of Tl and T1Cl Impurities on the Conductivity and Photoconductivity of Selenium	Sov Phys Solid State June 1960	It has been established that the values of the conductivity of selenium vary according to the concentration of thallium in the selenium.	I. P. Shapio
The Effect of Pressure on the Piezoelectric Properties of Barium Titanate	Sov Phys Solid State June 1960	The dependence of the piezoelectric effect induced by polarization upon hydrostatic (three-dimensional) and uni-directional pressure for single crystal of $BaTiO_3$ is investigated.	B. A. Rotenberg
Electron-Hole Pair Production	US Govt Res Repts July 15 1960 LC $4.80 PB 145733	For a fairly general band structure, the transition probability is computed for across-the-gap impact ionization by a fast particle in a semiconductor.	D. L. Dexter
Silicon Crystal Perfection Study	US Govt Res Repts July 15 1960 LC $3.00 PB 146486	Study includes high perfection silicon crystals, low temperature mobility in *p*-type germanium, and non-injecting contacts for *n*-type germanium.	H. J. Yearian
Semiconductor Research	US Govt Res Repts July 15 1960 LC $6.30 PB 145883	Gauge transformation in perturbation theory. Preparation and analysis of crystals. Conductivity at high electric fields (Cu-doped Ge).	Purdue Research Foundation
Semiconductor Research	US Govt Res Repts July 15 1960 LC $6.30 PB 145884	Preparation and testing of single crystals. Infrared absorption in neutron irradiated silicon.	Purdue Research Foundation
Transmission Line Formulation for Semiconductors	US Govt Res Repts July 15 1960 LC $3.30 PB 145825	Green's function of a rectangular waveguide is shown to be approximately a free space (scalar) Green's function augmented by a *finite* number of plane waves.	H. Kurss
Transmission Line Formulation for Semiconductors	US Govt Res Repts July 15 1960 LC $3.30 PB 145986	A "transmission line" analysis of wave propagation in media with a transverse periodicity is given.	H. Kurss
Study of Noise in Semiconductors and Semiconductor Devices	US Govt Res Repts July 15 1960 LC $19.80 PB 146490	The gain, bandwidth, and noise figure of wideband transistor amplifiers are discussed.	A. van der Ziel
Study of Noise in Semiconductors and Semiconductor Devices	US Govt Res Repts July 15 1960 LC $12.30 PB 146028	A program of measurement of noise in silicon transistors has been undertaken. Preliminary results of this program are presented in this report.	A. van der Ziel
Research in Radiation Damage in Semiconductors	US Govt Res Repts July 15 1960 LC $3.00 PB 161673	The purpose of the experimental program was to study the effect of irradiation on semiconducting materials, and to apply this knowledge to fabricate a radiation-resistant diode.	J. W. Harity H. Horinje et al
Some Surface Properties of Indium Anti-Monide Crystals I. Low-Energy Electron Diffraction Measurements	US Govt Res Repts July 15 1960 LC $4.80 PB 145930	Low energy electron diffraction studies have been made of five surfaces of InSb which were cleaned by argon ion bombardment.	H. E. Farnsworth J. D. Dillon Jr. et al
Microwave Techniques in Measurement of Lifetime in Germanium	US Govt Res Repts July 15 1960 LC $4.80 PB 145753	A new method of measurement of lifetime in germanium single crystals is described.	H. Jacobs F. A. Brand
Research and Experimental Work on Microwave Transistors	US Govt Res Repts July 15 1960 LC $4.80 PB 145877	Transistor action in depletion-layer devices is achieved when the bias on the injecting probe is more positive than the floating potential is negative.	M. M. Fortini et al
Thermoelectricity Abstracts	US Govt Res Repts July 15 1960 OTS $2.50	This, the third bibliography in a series, includes current periodicals and research reports received in the Library of the U.S. Naval Research Laboratory, and index and abstract journals.	Naval Research Laboratory
Variable Capacitor Microwave Diodes	US Govt Res Repts July 15 1960 LC $9.30 PB 145960	A technique is discussed for measuring varactor cut-off frequency at X-band.	Microwave Associates Inc.
Transistor Life Experience	US Govt Res Repts July 15 1960 OTS $1.00 PB 161675	The TX-O computer started operation in April, 1956 and in April, 1958 it had been in operation for 6000 hours. At this time 660 transistors were retested, and the results reported.	D. J. Eckl P. A. Fergus R. L. Burke
70 Ampere High Power Silicon Controlled Rectifier, Research and Development	US Govt Res Repts July 15 1960 LC $6.30 PB 145815	This report includes two-terminal asymmetrical and symmetrical silicon negative resistance switches.	C. N. Hall R. P. Lyon
70 Ampere High Power Silicon Controlled Rectifier, Research and Development Program	US Govt Res Repts July 15 1960 LC $15.30 PB 145816	Junction feasibility studies have been completed, and the alloy-diffused process has been chosen for fabrication.	G. N. Hall R. P. Lyon
Theory of the Germanium Diode Microwave Switch	US Govt Res Repts July 15 1960 LC $3.30 PB 146060	The application of a theory of microwave detection to the problem of *p-n* semiconductor junction behavior at microwave frequencies is discussed.	E. F. Turner R. V. Garver J. A. Rosado
Effects of Pulsed Nuclear Radiation on Nonoperating Tubes and Transistors	US Govt Res Repts July 15 1960 LC $3.30 PB 146077	Measured transistor parameters suffered large percentage changes from radiation greater than $3x10^{13}Pu^{239}$ nvt.	H. G. Chandler
High Temperature Semiconductor Devices	US Govt Res Repts July 15 1960 OTS $2.75 PB 161541	Purification, crystal growth, and evaluation of the compounds, GaAs and InP.	A. Amith L. Eckstron et al
Research and Development of Germanium PNP Junction Switching Transistors	US Govt Res Repts July 15 1960 LC $4.80 PB 146167	The lowest possible resistivity combined with the widest possible alloyed base width leads to fewer burnouts in the switching test.	P. L. Meretsky

CHARACTERISTICS CHART of NEW TRANSISTORS

MANUFACTURERS (In Order of Code Letters)

ARA— Advanced Research Associates, Inc.
AEG— Allgemeine Elecktricitats-gesellschaft
AMP— Amperex Electronic Corp.
AEIE— Associated Electrical Industries Ediswan Div.
AEIL— Associated Electrical Industries Export
BEN— Bendix Corp.
BOG— Bogue Electric Mfg. Co.
CBS— CBS Electronics
CPC— C.P. Clare Transistor Corp.
CDLF— Compagnie des Lampes
CSF— Compagnie Generale
CRY— Crystalonics, Inc.
CTP— Clevite Transistor Products, Inc.
DEL— Delco Radio Div., General Motors Corp.
ETC— Electronic Transistor Corp.
FSC— Fairchild Semiconductors Corp.
FTHF— French Thompson-Houston Semiconductor Dept.
GECB— General Electric Co., Ltd.
GE— General Electric Co.
GIC— General Instrument Corp.
GEM— Great Eastern Mfg. Co.
HITJ— Hitachi Ltd., Mushashi Works
HIVB— Hivac Ltd.
HSD— Hoffman Semiconductor Div.
HUG— Hughes Aircraft Co.
IND— Industro Transistor Corp.
INTG— Intermetall
KOKJ— Kobe Kogyo Corp.
LCTF— Labortoire Central de Telecommunications
MIN— Minneapolis-Honeywell Regulator Co.
MISI— Mistral
MOT— Motorola, Inc.
MUL— Mullard Ltd.
NAC— National Semiconductor Corp.
NTLB— Newmarket Transistors Ltd.
NIPJ— Nippon Electric Co. Ltd.
PSI— Pacific Semiconductors. Inc.
PHI— Philco Corp., Lansdale Division, Semiconductor Operations
RAY— Raytheon Co.
RCA— Radio Corp. of America, Semiconductor Div.
RADF— La Radiotechnique, Div. Tubes Electroniques
RHE— Rheem Semiconductor Corp.
ROSG— Dr. ing. Rudolph Rost
SANJ— Sanyo Electric Co. Ltd.
SIE— Siemens & Halske Aktiengesellschaft
SIL— Silicon Transistor Corp.
SGSI— Societa General Semiconduttori
SONY— Sony Corp.
SPE— Sperry Rand Corporation
SPR— Sprague Electric Co.
STCB— Standard Telephone & Cables, Ltd.
TKAD— Suddeutsche Telefon-Apparate-, Kabel und Drahtwerke
SYL— Sylvania Electric Products Inc.
TOSJ— Tokyo Shibaura Electric Co.
TRA— Transitron Electronic Corp.
TFKG— Telefunken Ltd.
TI— Texas Instruments Incorporated
TIIB— Texas Instruments Ltd.
TUN— Tung-Sol Electric, Inc.
UST— U. S. Transistor Corp.
WEC— Western Electric Co., Inc.
WTC— Western Transistor Corp.
WEST— Westinghouse Electric Corp.

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C: Pc (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics: $f_{\alpha\beta}$ (mc)	Gain: PARAMETER and (condition)	VALUE	MFR. See code at end of chart
2N719A	3,4,5	NPNPL	Si	1.8W	97.3Ø	120	80	100	h_{FE}: I_C-150ma	30Ø	FSC
2N720A	3,4,5	NPNPL	Si	1.8W	97.3Ø	120	100	110	h_{FE}: I_C-150ma	65Ø	FSC
2N779	5	PNPD	Ge	60	1250	15	15	450†	h_{FE}: I_C- 10ma	90	PHI
2N799	5		Ge	70	850			12	h_{fe}: I_C- 30ma	45	RAY
2N805	5		Ge	70	850			17	h_{fe}: I_C- 30ma	80	RAY
2N811	5		Ge	70	850			10	h_{fe}: I_C- 30ma	80	RAY
2N813	5		Ge	70	850			20	h_{fe}: I_C- 30ma	140	RAY
2N815	5		Ge	70	850			8.0	h_{fe}: I_C- 30ma	110	RAY
2N821	5		Ge	70	850			10	h_{fe}: I_C- 30ma	70	RAY
2N846	5	PNPD	Ge	60	1250	15	15	450†	h_{FE}: I_C- 10ma	50	PHI
2N870	3,4,5	NPNPL	Si	1.8W	97.3Ø	100	80	110	h_{FE}: I_C-150ma	65Ø	FSC
2N871	3,4,5	NPNPL	Si	1.8W	97.3Ø	100	80	130	h_{FE}: I_C-150ma	120Ø	FSC
2N1319	5	PNPA	Ge	120		20		6.0	h_{FE}: I_E-400ma	30	RCA
2N1474	2	PNPA	Si	250	600	60	60	1.5	h_{fe}: I -1.0ma	26	SPE
2N1474A	2	PNPA	Si	250	600	60	60	2.5	h_{fe}: I -1.0ma	30	SPE
2N1475	2	PNPA	Si	250	600	60	60	1.5	h_{fe}: I -1.0ma	60	SPE
2N1476	2	PNPA	Si	250	600	100	100	1.5*	h_{fe}: I -1.0ma	24	SPE
2N1477	2	PNPA	Si	250	600	100	100	1.5*	h_{fe}: I -1.0ma	45	SPE
2N1605A	5	NPNA	Ge	200	375	40	24	6.0	h_{FE}: I_C- 20ma	60	SYL
2N1658	3	A	Ge	15W	5.0	80	50	.50	h_{FE}: I_C-.20A	50	MIN
2N1659	3	A	Ge	15W	5.0	60	40	.50	h_{FE}: I_C-.20A	50	MIN
2N1726	4	PNPD	Ge	60	1250	20	20	150*	h_{FE}: I_C-1.0ma	40-120	PHI
2N1727	4	PNPD	Ge	60	1250	20	20	150*	h_{FE}: I_C-1.0ma	20-150	PHI
2N1728	4	PNPD	Ge	60	1250	20	20	150*	h_{FE}: I_C-1.0ma	25-100	PHI
2N1779	5	NPNA	Ge	100	750	25	20	5.0	h_{FE}: I_C- 30ma	60	SYL
2N1780	5	NPNA	Ge	100	750	25	25	8.0	h_{FE}: I_C- 30ma	70	SYL
2N1781	5	NPNA	Ge	100	750	25	25	6.0	h_{FE}: I_C- 20ma	60	SYL
2N1782	5	PNPA	Ge	100	750	30	20	8.0	h_{FE}: I_C- 10ma	90	SYL
2N1783	5	PNPA	Ge	100	750	30	15	8.0	h_{fe}: I_C-1.0ma	60	SYL
2N1784	5	PNPA	Ge	100	750	30	20	12	h_{FE}: I_C- 10ma	40	SYL

NOTATIONS

Under Use

1- Low power a-f equal to or less than 50 mw
2- Medium power a-f 50 mw and equal to or less than 500 mw
3- Power>500 mw
4- r-f/i-f
5- Switching and Computer
6- Low Noise
7- Photo
8- Mixer
9- Local Oscillator
Ø- Revised Spec.
10- Chopper
11- Matched Pair

Under Gain Value

Ø - Pulsed

Under Type

A- Alloyed
D- Diffused or Drift
F- Fused
G- Grown
H- Hook Collector
M- Microalloy
PL- Planar
Me- Mesa
O- Other
S- Surface Barrier
UNI - Unijunction Transistor
Y - Symmetrical
§ Tetrode

Under fab

* — Maximum Frequency
\# — Figure of Merit
Δ — f_e
Ø - Minimum
† - f_T (Gain Bandwidth Product)
Ø— f_{os} max. (Max. freq. of oscillation)

Under Derating

Ø - Infinite heat sink

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C				Typical Characteristics			MFR. See code at start of charts
				Pc (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha\beta}$ (mc)	Gain: PARAMETER and (condition)	Gain: VALUE	
2N1889	3,4,5	NPNPL	Si	3.0W	58.3∅	100	80	110	h_{FE}:I_C-150ma	70∅	FSC
2N1890	3,4,5	NPNPL	Si	3.0W	58.3∅	100	80	130	h_{FE}:I_C-150ma	120∅	FSC
2SA153	1	PNPG	Ge	20		15		60	h_{fe}:I_c-1.0ma	60	NIPJ
2SA154	1	PNPG	Ge	20		15		50	h_{fe}:I_c-1.0ma	20	NIPJ
2SA155	1	PNPG	Ge	20		15		55	h_{fe}:I_c-1.0ma	30	NIPJ
2SA156	1	PNPG	Ge	20		15		55	h_{fe}:I_c-1.0ma	50	NIPJ
2SA157	1	PNPG	Ge	20		15		65	h_{fe}:I_c-1.0ma	50	NIPJ
2SA159	1	PNPG	Ge	20		15		55	h_{fe}:I_c-1.0ma	50	NIPJ
2SA160	1	PNPG	Ge	20		15		55	h_{fe}:I_c-1.0ma	60	NIPJ
2SA161	4	PNPO	Ge	50		20			h_{fe}:I_e-1.0ma	12db	SONY
2SA162	4	PNPO	Ge	50		20			h_{fe}:I_e-1.0ma	12db	SONY
2SA163	4	PNPO	Ge	50		20			h_{fe}:I_e-1.0ma	12db	SONY
2SA164	4	PNPO	Ge	50		20			h_{fe}:I_e-1.0ma	12db	SONY
2SA165	4	PNPO	Ge	50		20			h_{fe}:I_e-1.0ma	12db	SONY
2SA166	4	PNPO	Ge	50		20			h_{fe}:I_e-1.0ma	12db	SONY
2SA167	2	PNPA	Ge	125	400	20		10	h_{fe}:I_c-1.0ma	70	NIPJ
2SA168	2	PNPA	Ge	175	280	20		10	h_{fe}:I_c-1.0ma	70	NIPJ
2SA169	2	PNPA	Ge	125	400	20		15	h_{FE}:I_C- 10ma	70	NIPJ
2SA170	2	PNPA	Ge	175	280	20		15	h_{FE}:I_C- 10ma	70	NIPJ
2SA171	2	PNPA	Ge	125	400	20		8.0	h_{FE}:I_C- 10ma	60	NIPJ
2SA172	2	PNPA	Ge	175	280	20		8.0	h_{FE}:I_C-200ma	60	NIPJ
2SA173	2	PNPA	Ge	125	400	20		4.0	h_{FE}:I_C- 10ma	60	NIPJ
2SA174	2	PNPA	Ge	175	280	20		4.0	h_{FE}:I_C- 10ma	60	NIPJ
2SA180	1	PNPA	Ge	50		15		12	h_{fe}:I_e-1.0ma	70	SANJ
2SA181	1	PNPA	Ge	50		15		8.0	h_{fe}:I_e-1.0ma	47	SANJ
2SA182	1	PNPA	Ge	50		15		5.0	h_{fe}:I_e-1.0ma	27	SANJ
2SA183	1	PNPA	Ge	50		15		16	h_{fe}:I_e-1.0ma	30	SANJ
2SA201	1	PNPA	Ge	30		15		8.0	h_{fe}:I_e-1.0ma	49	SANJ
2SA202	1	PNPA	Ge	30		15		12	h_{fe}:I_e-1.0ma	70	SANJ
2SA203	1	PNPA	Ge	30		15		5.0	h_{fe}:I_e-1.0ma	31	SANJ
2SA204	2	PNPA	Ge	150		30		6.0	h_{fe}:I_e-1.0ma	40	NIPJ
2SA205	2	PNPA	Ge	200		30		5.0	h_{FE}:I_C- 10ma	40	NIPJ
2SA206	2	PNPA	Ge	200		30		7.0	h_{FE}:I_C- 10ma	55	NIPJ
2SA207	2	PNPA	Ge	200		30		12	h_{FE}:I_C- 10ma	60	NIPJ
2SA213	1	PNPG	Ge	15		15		130	h_{fe}:I_c-1.0ma	25	NIPJ
2SA214	1	PNPG	Ge	15		15		130	h_{fe}:I_c-1.0ma	25	NIPJ
2SA215	1	PNPG	Ge	15		15		110	h_{fe}:I_c-1.0ma	40	NIPJ
2SA216	1	PNPG	Ge	15		15		110	h_{fe}:I_c-1.0ma	40	NIPJ
2SA218	1	PNPD	Ge	50		20		25	h_{fe}:I_e-1.0ma	48	SANJ
2SA219	1	PNPD	Ge	50		20		40	h_{fe}:I_e-1.0ma	50	SANJ
2SA221	1	PNPD	Ge	50		20		50	h_{fe}:I_e-1.0ma	75	SANJ
2SA223	1	PNPD	Ge	50		20		64	h_{fe}:I_e-1.0ma	50	SANJ
2SA224	1	PNPD	Ge	50		20		80	h_{fe}:I_e-1.0ma	80	SANJ
2SA226	1	PNPD	Ge	50		20		95	h_{fe}:I_e-1.0ma	120	SANJ
2SA228	2	PNPD	Ge	100		80		30	h_{fe}:I_e-1.0ma	70	SANJ
2SB22	2	PNPA	Ge	170		25			h_{fe}:I_e- 30ma	95	SANJ
2SB23	1	PNPA	Ge	40		15			PG:I_e-1.0ma	35db	SANJ
2SB100	2	PNPA	Ge	100		30		1.2	h_{fe}:I_e-1.0ma	60	NIPJ
2SB101	2	PNPA	Ge	125	400	30		1.2	h_{fe}:I_e-1.0ma	60	NIPJ
2SB102	2	PNPA	Ge	180	270	30		1.2	h_{fe}:I_e-1.0ma	60	NIPJ
2SB103	2	PNPA	Ge	125	400	30		1.2	h_{FE}:I_C- 50ma	90	NIPJ
2SB104	2	PNPA	Ge	180	270	30		1.2	h_{FE}:I_C- 50ma	90	NIPJ
2SB105	2	PNPA	Ge	500	100	30		.50	h_{FE}:I_C-250ma	70	NIPJ
2SB106	3	PNPA	Ge		17	30		.50	h_{FE}:I_C-.20A	70	NIPJ
2SB107	3	PNPA	Ge		5.0	30		.40	h_{FE}:I_C-1.0A	70	NIPJ
2SB107A	3	PNPA	Ge		2.5	60	60	.40	h_{FE}:I_C-1.0A	70	NIPJ
2SB108	3	PNPA	Ge		100	40			h_{FE}:I_C-.20A	70	NIPJ
2SB108A	3	PNPA	Ge		100	60			h_{FE}:I_C-.20A	70	NIPJ
2SB108B	3	PNPA	Ge		100	80	80		h_{FE}:I_C-.20A	70	NIPJ
2SB109	3	PNPA	Ge		17	40			h_{FE}:I_C-.20A	70	NIPJ

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C				Typical Characteristics			MFR. See code at start of charts
				P_C (mw)	DERATING °C/W	V_{CB}	V_{CE}	$f_{\alpha\beta}$ (mc)	Gain: PARAMETER and (condition)	Gain: VALUE	
2SB109A	3	PNPA	Ge		17	60			$h_{FE}:I_C$-.20A	70	NIPJ
2SB109B	3	PNPA	Ge		17	80			$h_{FE}:I_C$-.20A	70	NIPJ
2SB110	2	PNPA	Ge	70	700	25		.70	$h_{FE}:I_C$-200ma	30	NIPJ
2SB111	2	PNPA	Ge	70	700	25		.70	$h_{FE}:I_C$-200ma	45	NIPJ
2SB112	2	PNPA	Ge	70	700	25		1.0	$h_{fe}:I_e$-1.0ma	60	NIPJ
2SB113	2	PNPA	Ge	70	700	25		1.0	$h_{fe}:I_e$-1.0ma	80	NIPJ
2SB114	2	PNPA	Ge	70	700	25		1.0	$h_{FE}:I_C$- 20ma	85	NIPJ
2SB115	2	PNPA	Ge	70	700	25		1.5	$h_{FE}:I_C$- 20ma	85	NIPJ
2SB116	2	PNPA	Ge	70	700	25		1.5	$h_{FE}:I_C$- 20ma	110	NIPJ
2SB117	2	PNPA	Ge	70	700	25		1.5	$h_{FE}:I_C$- 20ma	140	NIPJ
2SB161	2	PNPA	Ge	125	400	30		.65	$h_{FE}:I_C$- 50ma	50	NIPJ
2SB162	2	PNPA	Ge	180	280	30		.65	$h_{FE}:I_C$- 50ma	50	NIPJ
2SB163	2	PNPA	Ge	125	400	30		.80	$h_{FE}:I_C$- 50ma	70	NIPJ
2SB164	2	PNP	Ge	180	280	30		.80	$h_{FE}:I_C$- 50ma	70	NIPJ
2SB165	2	PNP	Ge	125	400	30		1.0	$h_{FE}:I_C$- 50ma	100	NIPJ
2SB166	2	PNP	Ge	180	280	30		1.0	$h_{FE}:I_C$- 50ma	100	NIPJ
2SB185	2	PNPA	Ge	150		25			$h_{fe}:I_e$- 30ma	45	SANJ
2SB186	2	PNPA	Ge	150		25			$h_{fe}:I_e$- 30ma	170	SANJ
2SB187	2	PNPA	Ge	150		25			$h_{fe}:I_e$- 30ma	100	SANJ
2SB188	2	PNPA	Ge	150		25					SANJ
2SB215	3	PNPA	Ge		2.5Ø	100			$h_{FE}:I_C$-1.0A	70	SANJ
2SB216	3	PNPA	Ge		2.5Ø	60			$h_{FE}:I_C$-.20A	70	SANJ
2SB217	3	PNPA	Ge		2.5Ø	20			$h_{FE}:I_C$-.20A	70	SANJ
C118	1,2	A	Si	250	540	12	6.0	1.0	$h_{FE}:I_C$-.01ma	15	CRY
C119	1,2	A	Si	250	540	12	6.0	1.0	$h_{FE}:I_C$-.01ma	25	CRY
CP98	5	PNPA	Ge	150	2500	65	65	4.0Ø	$h_{FE}:I_C$- 30ma	30min	CPC
CP398	5	PNPA	Ge	120	2400	105	105	1.0	$h_{FE}:I_C$-5.0ma	30min	CPC
PADT20	4	PNPAD	Ge	83	600	20		70	PG at 100Mc	12.5db	AMP
PADT21	4	PNPAD	Ge	83	600	20		70	Conv. at 10.7Mc	12db	AMP
PADT22	4	PNPAD	Ge	83	600	20		70	Conv. at 10.7Mc	35db	AMP
PADT23	4	PNPAD	Ge	100	600	35		70	PG at 1.5Mc	46db	AMP
PADT24	4	PNPAD	Ge	100	600	35		70	PG at 455Kc	61db	AMP
PADT25	4	PNPAD	Ge	100	600	35		70	IF at 10.7Mc	34.7db	AMP
PADT26	4	PNPAD	Ge	100	600	35		70	PG at 100Mc	14db	AMP
PADT27	4	PNPAD	Ge	100	600	35		70	Conv. at 262Kc	32db	AMP
PADT28	4	PNPAD	Ge	100	600	35		220	PG at 200Mc	14db	AMP
PADT30	4	PNPAD	Ge	100	600	25		220	PG at 200Mc	14db	AMP
PADT31	4	PNPAD	Ge	100	600	35		70	PG at 60Mc	14db	AMP
TK33C	5	NPNA	Ge	150	330	30	12	5.0	$h_{fe}:I_c$-1.0ma	40	STCB
TK34C	5	NPNA	Ge	150	330	20	6.0	11	$h_{fe}:I_c$-3.0ma	80	STCB
TK44C	2	PNPA	Ge	150	300	60	40	.50Ø	$h_{FE}:I_C$- 10ma	30	STCB
TK45C	2	PNPA	Ge	200	250	40	15	1.4	$h_{fe}:I_C$-1.0ma	66	STCB
TK46C	2	PNPA	Ge	200	250	20	10	50Ø	$h_{FE}:I_C$-5.0ma	15min	STCB
TK47C	2	PNPA	Ge	200	250	20		50Ø	$h_{FE}:I_C$-5.0ma	20min	STCB
TK200A	3	NPND	Si	2500		40	20	50†	$h_{FE}:I_C$- 20ma	8.0min	STCB
V6/2RJ	2	PNP	Ge	75		6.0		3.0	$h_{fe}:I_c$-1.0ma	30	NTLB
V6/4RJ	2	PNP	Ge	75		6.0		5.5	$h_{fe}:I_c$-1.0ma	50	NTLB
V6/8RJ	2	PNP	Ge	75		6.0		10	$h_{fe}:I_c$-1.0ma	80	NTLB
V10/1SJ	2	PNP	Ge	75		10		10	$h_{fe}:I_c$-1.0ma	66	NTLB
V10/2SJ	2	PNP	Ge	75		10		5.0	$h_{fe}:I_c$-1.0ma	66	NTLB
V15/10DP	3	PNP	Ge	10W		15			$h_{fe}:I_c$-200ma	18	NTLB
V15/20DP	3	PNP	Ge	10W		15			$h_{fe}:I_c$-200ma	24	NTLB
V15/30DP	3	PNP	Ge	10W		15			$h_{fe}:I_c$-200ma	38	NTLB
V30/10DP	3	PNP	Ge	10W		30			$h_{fe}:I_c$-200ma	18	NTLB
V30/20DP	3	PNP	Ge	10W		30			$h_{fe}:I_c$-200ma	24	NTLB
V30/30DP	3	PNP	Ge	10W		30			$h_{fe}:I_c$-200ma	38	NTLB
V60/10DP	3	PNP	Ge	10W		60			$h_{fe}:I_c$-200ma	18	NTLB
V60/20DP	3	PNP	Ge	10W		60			$h_{fe}:I_c$-200ma	24	NTLB
V60/30DP	3	PNP	Ge	10W		60			$h_{fe}:I_c$-200ma	38	NTLB
XC703	3	NPND	Si		200	60	40	1.5	$h_{FE}:I_C$-.20A	15min	AEIE
XC713	3	NPND	Si		100	60	40	1.25	$h_{FE}:I_C$-.75A	15min	AEIE
XC723	3	NPND	Si		2.5	60	40	1.0	$h_{FE}:I_C$-1.5A	10min	AEIE
XS104	5	PNPAY	Ge	150	330	21	12	2.0Ø	$h_{FE}:I_C$-100ma	18	AEIE

Market News . . .

Sales

The Electronics Division, Business and Defense Services Administration, U.S. Department of Commerce, has reported that for the first time since they have made their quarterly surveys, the output of semiconductor devices (transistors, diodes and rectifiers, and related devices) failed to increase. The following table shows estimated shipments of semiconductors during the second quarter 1960.

Category	Quantity (in thousands of units) Total	Military	Non-military	Value (in millions of dollars) Total	Military	Non-Mil
SEMICONDUCTOR DEVICES	75,959	23,131	52,828	134,664	64,788	69,876
Diodes, rectifiers and related devices ..	46,338	17,925	28,413	57,376	30,038	27,338
Germanium diodes and rectifiers	24,661	8,678	15,983	13,693	6,776	6,917
0-30 ma	14,199	4,861	9,338	7,178	3,594	3,584
31-100 ma	8,866	3,404	5,462	5,187	2,793	2,394
Over 100 ma	1,596	413	1,183	1,328	389	939
Silicon diodes and rectifiers	19,469	8,221	11,248	32,414	17,763	14,651
0-30 ma	3,291	1,912	1,379	4,993	3,637	1,356
31-100 ma	3,524	1,925	1,599	6,987	4,330	2,657
101-550 ma	6,703	2,657	4,046	9,338	4,872	4,466
551 ma—3 amps ..	4,151	1,379	2,772	5,509	2,464	3,045
Over 3 amps—35 amps	1,664	287	1,377	3,423	1,337	2,086
Over 35 amps	136	61	75	2,164	1,123	1,041
Zener diodes	1,458	617	841	6,425	2,709	3,716
Microwave diodes ..	298	216	82	1,346	1,045	301
Infra-red and other semiconductor photo cells except solar cells	44	25	19	664	531	133
*Other	408	168	240	2,834	1,214	1,620
Transistors	29,621	5,206	24,415	77,288	34,750	42,538
Germanium	27,591	3,693	23,898	51,238	15,349	35,889
0-125 mw	10,840	2,099	8,741	20,115	7,364	12,751
126-999 mw	13,445	1,238	12,207	21,734	5,188	16,546
1 watt and over ..	3,306	356	2,950	9,389	2,797	6,592
Silicon	2,030	1,513	517	26,050	19,401	6,649

*Includes diodes and rectifiers made from materials other than silicon and germanium, tunnel diodes, controlled rectifiers, solar cells, and other special semiconductor devices which must be combined to avoid disclosure of proprietary information.

Transistor sales at the factory made the heaviest monthly gains of 1960 during September, with 3,240,799 more units sold than during the previous month, according to figures released by the Marketing Data Department of the Electronic Industries Association. Revenue from sales increased by $5,702,260. Cumulative sales last year were 32,352,839 units ahead of the total for the same period in 1959, while revenue was up by $67,861,443. The following table shows the EIA statistics through September:

	Factory Sales (Units)	*Factory Sales (Dollars)*
September	12,973,792	$28,442,229
August	9,732,993	22,739,969
July	7,070,884	18,083,802
June	10,392,412	27,341,733
May	9,046,237	24,146,373
April	9,891,236	23,198,576
March	12,021,506	28,700,129
February	9,527,662	24,831,570
January	*9,606,630*	*24,714,580*
Jan.-Sept. '60	90,263,352	222,198,961
Jan.-Sept. '59	57,910,513	154,337,518

Japanese Ministry of Trade and Industry has revised upward its estimate of transistor output. Estimates for their five year plan are:

1960	127,000,000
1961	178,000,000
1962	234,000,000
1963	282,000,000
1964	314,000,000

Rheem Semiconductor Corp. has opened a new sales office in San Diego, Cal.

Prices

RCA has developed a drift-field transistor for use in high fidelity sound equipment. This unit is expected to be sold for less than $2 each.

Pacific Semiconductors Inc. has developed a triple diffused mesa silicon power transistor, type PT530 rated at 5w at 30mc. Housed in a TO-8 package this *n-p-n-n* configuration is available at $125 each.

Hughes has announced new price reductions from $9 to $19 per unit on their silicon transistors. In quantities of 1 to 99 these prices apply to: their high speed silicon mesa switching transistor series 2N1254 to 59; their standard TO-5 package silicon alloy transistors 2N1228 to 34, and their high frequency mil-spec mesa transistors 2N1196 and 2N1197.

The firm has also announced prices on several of their new alloy-junction medium speed transistors. Prices per unit in lots of 1 to 99 for type 2N327A is $5.20; 2N328A is $7.80, and 2N329A is $15.60.

Sylvania has available two epitaxial germanium mesa transistors. Type SYL 2300 is priced each at $27 in quantities up to 99 and at $18 for 100-999, while the SYL 2301 is $18 for 1-99 and $12 for 100-999. The firm has also developed another series of ten *p-n-p* germanium alloy transistors, types 2N1372 through 2N1381 utilizing the TO-5 package. Designed for applications including audio amplifiers, servo amplifiers, and motor control these units are priced in 1-99 quantities from 75¢ to $1.88 each and from 50¢ to $1.25 for 100-999 quantities.

Kulite-Bytrex Corp., Newton, Mass., is marketing a series of 21 semiconductor strain gauges. Prices for the units vary from $15 to $25 each depending upon specifications.

Suppliers

Products and services of CBS's Mechanical Equipment Department are now available to outside organizations. The department provides a new source to industrial and military contractors for the design, development, and construction of highly specialized mechanical and electro-mechanical equipment and systems.

Philco Corporation, Lansdale Division, Semiconductor Operations, is making available modular controlled atmosphere systems designed and built by their recently formed equipment development and manufacturing operation. The equipment features vacuum machinery and dry boxes for industrial processing where precise control of dust and atmospheric conditions are necessary.

VHM Coporation, of Oakland, Calif., will manufacture and market six different types of electronic test instruments and systems under a license from Lenkurt Electric who developed the equipment. Covered under the license is a system that can test and sort thousands of circuit elements such as transistors, diodes, capacitors and resistors in a fraction of the time now required.

Vacuum—Electronics Corp. of Plainview, New York, manufacturers of leak detection and high vacuum equipment has opened a second California field office located in Hollywood to provide sales and service for Southern California. The company recently completed construction of a 75,000 square foot manufacturing plant in Plainview.

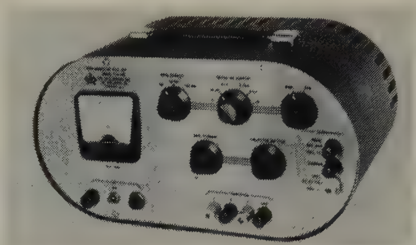
Three metal and chemical firms in Japan have entered the silicon refining field for electronic applications in 1960. These are Showa Denko Co., Ltd., Shin Nippon Chisson Hiryo K.K. and Nippon Denshi Kinzoku K.K.

Kollstan Semiconductor Elements Inc. has established regional sales offices in Los Angeles, Chicago and New York City to handle their new high volume production of Czochralski and float zone single crystal slices, dice and special silicon and germanium forms.

(*Continued on page 59*)

New Products

Semiconductor Tester



PRL announces Model TT8-100 semiconductor tester for evaluating and inspecting Transistors, Zener Diodes, Rectifiers, and Tunnel Diodes. Features a current limited source to prevent damage to any semiconductor under test. Scope calibration voltages of 5 volts for vertical and 80 volts for horizontal are provided.

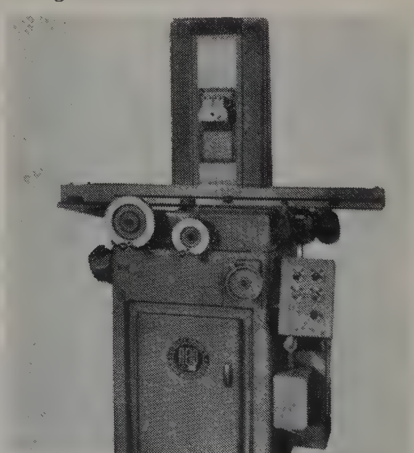
Circle 127 on Reader Service Card

Electronic Metals and Compounds

Eagle-Picher Company Chemicals and Metals Division has expanded its line of electronic metals and compounds with the development of 16 new products. The complete list includes: Germanium, in the form of Dioxide, First Reduction Metal, Intrinsic Metal and Single Crystal forms; Germanium Tetrachloride, Germanium Tetrabromide, Germanium Tetraiodide; Silicon Tetrabromide, Silicon Tetraiodide; Boron Tribromide, Boron Oxide, Cadmium Sulfide (Ultra High Purity) in Single Crystals, Powder and Infrared Transmission Windows; the Intermetallics such as Gallium Arsenide, Cadmium Telluride and Zinc Sulfide; High Purity Elements of Boron, Cadmium and Zinc.

Circle 104 on Reader Service Card

Dicing Machine



Reid Brothers, Inc., has developed a special dicing machine for germanium and silicon wafers used by semiconductor manufacturers. The Dicer is a heavy, rugged machine built for maximum stability and vibration-free operation. Hand operated, cross feed controls are accessible and provide accurate, visual measurement scales that can be seen with minimum effort. Both silicon carbide and diamond cutting tools perform efficiently.

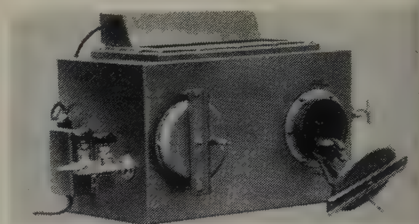
Circle 101 on Reader Service Card

New Silicone Rubber

A new "super-thin" fluid silicone rubber that cures without heat promises to simplify and improve potting and encapsulating of electronic units. Dow Corning Silastic RTV 521, when fully cured, remains rubbery from —70 to 500°F; withstands temperatures to 600°F for short times.

Circle 105 on Reader Service Card

Vacuum Dry Box



Constructed of 14 gauge stainless steel with special interior reinforcements, Kewaunee Scientific Equipment Dry Box provides a small working area which can be readily evacuated to a vacuum of approximately 28" of Mercury with a standard laboratory type of vacuum pump. It is particularly useful in the preparation of samples for spectographic analysis and/or minute metallurgical preparations that cannot tolerate oxygen contamination.

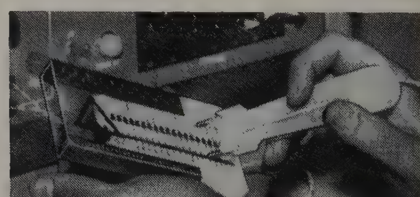
Circle 102 on Reader Service Card

Ultra High Purity Lead

Lead 99.999+% pure to meet the critical requirements of semiconductor device producers is available from Alpha Metals, Inc. This semiconductor grade lead is free of Group 3B elements (boron, aluminum, gallium, indium and thallium), and of Group 5B elements (phosphorous, arsenic, antimony and bismuth). Contains less than 1 part in each million of either copper or silver. Other elements are not detected by spectrographic analysis. Available in bars or special shapes.

Circle 106 on Reader Service Card

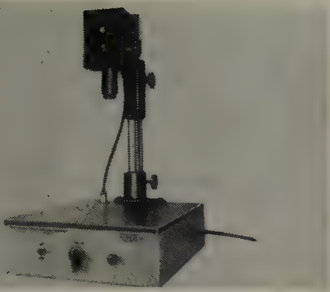
Diode Package



Delta Semiconductors has introduced a new diode shipping package, called Test-Pak, that allows the purchaser to test incoming diodes without removing them from the package. The package consists of a styro-foam block which encases the diodes and holds the leads in a rigid position. A channel, cut in the styro-foam of both sides of the diodes, exposes a portion of each lead. A special test jig, furnished with each shipment, plugs into the tester. The operator simply runs the prongs of the test jig down the channel to make contact with both leads of each diode.

Circle 122 on Reader Service Card

park Gap



Electro Impulse Laboratory, Inc., an-
ounces a new spark gap which is useful
s a pulsed light source for such applica-
ions as lifetime measurements, etc. It is
esigned to operate at 5,000 volts for the
G-5, 10,000 volts for the SG-10 and
0,000 volts for the SG-20. The spark gaps
re sealed units filled with a mixture of
are gases and they give a higher flash
ntensity than comparable air gaps.

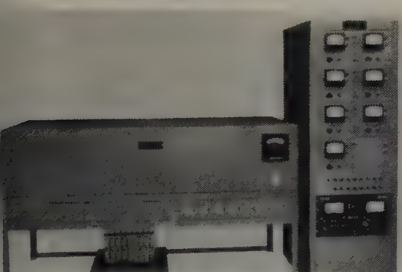
Circle 103 on Reader Service Card

ilicon Zener Voltage Rectifiers

A new series of Silicon Zener Voltage
egulators, with voltage ranges in each
ating from 5.6 to 100 volts, has been in-
roduced by the Semiconductor Division,
arkes Tarzian, Inc. The series are in
hree power classifications, 1/4 watt, one
vatt, and 10 watts. These are constant
voltage devices used to control output
voltage of power sources and as voltage
eference elements capable of operating
over a wide temperature range.

Circle 108 on Reader Service Card

iode Classifier



Dynatran Model 1820 Automatic Diode
Classifier classifies diodes at a rate in ex-
ess of 1200 per hour. The devices are
ed into a conveyor system in the oven
nit where they are brought up to tem-
erature (adjustable up to 200°C) and
ested for reverse leakage characteristics
t various reverse voltages. They are
hen automatically ejected into the cor-
ect bin and counted. Shorted and open
iodes are also separated.

Circle 107 on Reader Service Card

rafting Aid

A new product, recently introduced by
ENSCA, (Engineering and Science Aids
Co.,) is intended to reduce substantially
he valuable time spent in drafting elec-
ronic circuit diagrams for technical
rticles and production drawings. SE-
LECT-A-CIRCUIT consists of all ASA
nd IRE electrical symbols, individually
printed on self-adhesive matte acetate.
Technical personnel without drafting ex-
perience can easily produce fine quality
ircuit diagrams. Coordinated assort-
ments, individually boxed, permit cir-
uit designers to construct many circuit
llustrations of transistors, relays, diodes
tc.

Circle 135 on Reader Service Card

Germanium Transistor Series

A series of *p-n-p* germanium alloy transistors for use in audio amplifiers, servo amplifiers, intercommunications systems, and motor control applications, has been announced by Sylvania. Types 2N1372 to 2N1381 exhibit linear beta, low distortion and high power gain. Designed for medium frequency switching in both commercial and military equipment, the units have a maximum collector current of 200 ma, maximum power dissipation of 250 mw, and maximum junction temperature of 100° C.

Circle 116 on Reader Service Card

Vacuum Pencil

A new K & S Vacuum Pencil has been developed for the simple and efficient handling of miniature pieces of metal, paper, glass, plastics, gems, biological specimens and other small particles down to 0.015 inch diameter. It has proven exceptionally useful in picking-up tiny dice and full-size wafers used in semiconductor and transistor manufacturing.

Circle 112 on Reader Service Card

Laboratory Enclosures

Perfect visibility of the entire working area is offered in new laboratory safety enclosures designed and fabricated for single unit installation or multiple-interconnected systems by S. Blickman, Inc. They feature an enlarged interior work area, and glove ports designed and located to afford convenience for interior manipulation. Different types of units are available for varying applications.

Circle 134 on Reader Service Card

Ultrasonic Cleaners

L & R Manufacturing Company announces the addition of two new ultrasonic cleaners to its Ultra-Cleen 320 Series. 320D (power output 55W) contains twin transducerized tanks, each with a 1¼ quart capacity; 320L, (power output 60W) features a single transducerized tank with a capacity of 3⅝ quarts. 320, the first of the Series, has a 1¼ quart transducerized tank and a 1¼ quart rinse tank. All units were designed to clean a large volume of precision parts at high speeds, with a minimum of attention. Operating frequency is 70-80KC.

Circle 126 on Reader Service Card

All Transistorized Oscilloscopes

A new line of totally-transistorized, portable oscilloscopes, measuring only 2¾″ x 3¼″ x 5½″, and weighing as little as 2 pounds (for the 1″ Model 150), has been announced by the EI Labs Division of Electro Instruments, Inc. They will operate on internal rechargeable batteries, *a-c* power line, or low voltage *d-c*, providing a precision, 1-, 2- or 3-inch display equivalent to a laboratory instrument.

Circle 125 on Reader Service Card

(Continued on page 61)

The ULTRA CLEEN '320' Series now has
3 'PEAK POWER' Ultrasonic Cleaners

'320'
One 1¼ qt. transducerized tank and one 1¼ qt. rinse tank.
$187.50*

'320-D'
Two 1¼ qt. transducerized tanks with selector switch.
$262.00*

'320-L'
One 3⅜ qt. transducerized tank.
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*With 1 pint of Hydro-Sonic Cleaning Solution Concentrate

All 3 Ultra-Cleen '320' ultrasonic cleaners are compact—yet their 'peak power' cleans a larger volume of larger pieces faster, more quickly, more efficiently. New electronic circuitry transmits ultrasonic sound waves directly from built-in generator to transducerized tank. Write today for details!

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THE NEW "70 SERIES" ALLIGATORS FEATURE:

Simple, direct, streamlined design, and lower cost than the famous "60 Series".

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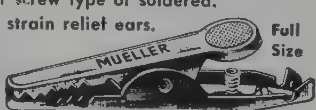

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Mueller Electric Co

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Circle No. 27 on Reader Service Card

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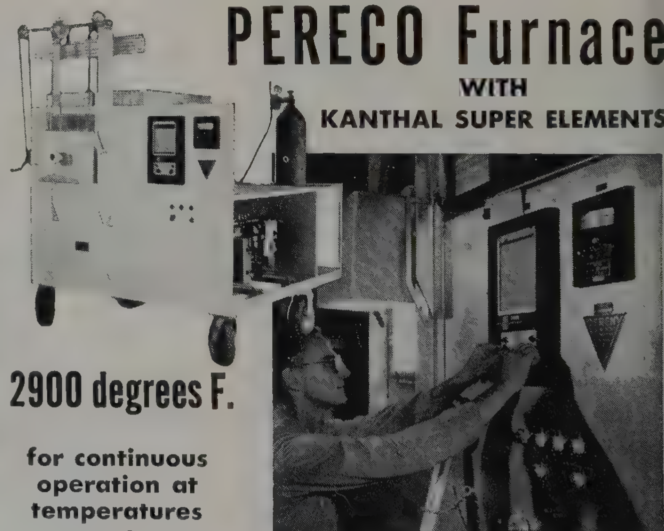

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Market News *(from page 53)*

Kearfott Semiconductor Corp., an affiliate of General Precision Inc., is in production of *p-n-p* germanium alloy junction transistors. The firm's initial line consists of 40 type numbers extending from 2N123 through 2N662.

Sarkes Tarzian Inc. is planning to market epitaxial rectifiers and other semiconductor devices.

National Semiconductor Corp. Danbury, Conn. has expanded its area sales setup to a tri-regional coast-to-coast marketing organization by establishing a regional sales office in Chicago to handle the Central States area.

Distributors

Texas Instruments Incorporated held product training seminars recently for distributors on diodes and rectifiers in New York, Camden, N.J. and Washington, D.C.

Rheem Semiconductor Corp. has named three new distributors. These are: L. B. Walker Radio Co., Denver; Moore Radio Supply Inc. Salt Lake City and Summit Distributors Inc. Buffalo. They will carry a complete line of Rheem silicon diodes and silicon mesa transistors in quantities up to 4999 for diodes and 999 for transistors.

Standard Rectifier Corp., Santa Ana, Calif., has announced the appointment of four additional distributors. They are Lafayette Radio Corporation, Boston; Almo Radio Co. (Industrial Headquarters), Philadelphia; Hollywood Radio and Electronics, Hollywood; and Terminal-Hudson Radio, New York.

The General Instrument Semiconductor Division has announced establishment of a new headquarters distributor organization to handle national sales, through a network of industrial distributors, of its semiconductor line of transistors, diodes and rectifiers.

Financial

Texas Instruments Incorporated has announced third quarter profits of $3,596,000 compared with $3,572,000 for the like period in 1959. Sales were $54,096,000 against $46,700,000. For the nine months ending Sept. 30 the net amounted to $11,517,000 against $9,877,000 in the same period last year. Sales totaled $170,147,000 compared with $140,899,000.

Philco has reported a sales increase of 5% for the first nine months of 1960, but earnings were off 52% compared with the 1959 period. Total sales were $297,101,000 compared with $283,516,000 the previous year. Earnings were $2,107,000 compared with 1959's $4,373,000. Earnings per common share in 1960 was 45¢ compared to $1 in 1959.

Hoffman Electronics Corp. has reported a net income for the first nine months of 1960 of $252,431 down 71% from the $1,565,366 earned in the first three quarters of 1959. The company has omitted the 15¢ quarterly dividend for the third quarter of 1959.

Silicon Transistor Corp. has announced sales, for the nine month period ending Sept. 30, of $800,000 and a profit of $55,000 against sales of $145,000 and a loss of $102,000 for the same period in 1959.

Transistor Electronics Corp., St. Louis Park, Minneapolis has reported sales of $312,557 for the first half of their fiscal year ending Oct. 31, 1960. This represents an increase of 149% over the $125,529 for the same period a year earlier.

Newark Electronics Corporation's net earnings for the fiscal year ending Aug. 31, 1960 were $166,000 equal to 55¢ a common share. Sales were $7,850,000 for the fiscal year.

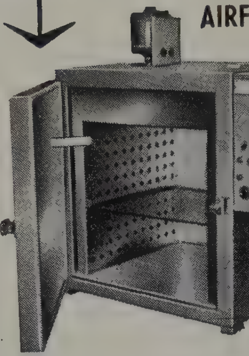
Silicon Transistor Corp., Carle Place, N. Y., has reported earnings of $145,000, equal to 29 cents a share on sales of over $800,000 in the nine month period ended September 30, 1960. The company had a loss of $102,000 a year earlier, in its first year of operation. In the third quarter of 1960, on sales of $288,000 STC earned $40,000. This amounted to eight cents per share earnings on 501,000 shares outstanding. Present backlog of orders now exceeds $500,000.

Wakefield Engineering, Inc., Wakefield, Mass., has announced the public sale of 100,000 shares of common stock. This is a step to expand the facilities for manufacturing its present line of Wakefield Semiconductor Cooling Devices.

(Continued on page 67)

BY POPULAR DEMAND!
8 CU. FT. VOLUME
. . . AT LOW COST

BLUE M STABIL-THERM® BATCH TYPE OVENS with HORIZONTAL AIRFLOW



Large Volume Capacity, Reliable mechanical convection batch ovens for production and tests associated with electronic paint, steel, rubber, aircraft, chemical and other industries. Elimination of alloy interiors and wattage proportioning reduced our cost and yours. However, care has been exercised to provide an adequate design suitable for reproducing good uniformity and control action. Utilizing horizontal airflow, quality motor/blower, ETERNA heater banks on a relatively uncomplicated control system, we offer a **good unit at reasonable cost.**

TEMPERATURE RANGES	Model Number	Watts Max.	Voltage 60 cy. A.C.	Complete Price
100°F. to 300°F.	OV-586	1750	115V/1 Ph.	$498.00
	OV-587		230V/1 Ph.	508.00
100°F. to 500°F.	OV-588	4000	230V/1 Ph.	595.00
	OV-588A		230V/3 Ph.	615.00

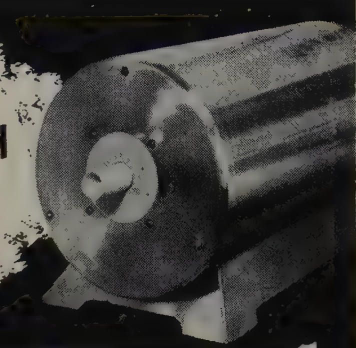
All Models: 24" x 25" x 24" (I.D.)

®

BLUE M Electric Company BLUE ISLAND, ILL.
MANUFACTURERS AND DESIGNERS
COMPLETE TEMPERATURE CONTROL EQUIPMENT

Circle No. 33 on Reader Service Card

2370°F continuously at low cost



KANTHAL® laboratory furnaces

Proven dependability, long life and low cost make these Kanthal furnaces ideal for a wide range of general laboratory and production applications. For intermittent temperatures to 2460°F, furnaces are designed to take fullest advantage of Kanthal REH ceramic tube elements, wound with world recognized Kanthal A-1 resistance alloy.

Furnaces are supplied complete, ready for use. Type RH-1 includes thermocouple and safety fuse. Type RH-2 is furnished with transformer and either temperature indicator with manual timer or fully-automatic temperature controller. Standard chamber I.D.'s are 1-9/16", 2-3/4" or 4" in either 7-7/8" or 19-3/4" lengths. Elements and parts also available separately. Write for brochure.

KANTHAL **THE KANTHAL CORPORATION**
19 Amelia Pl., Stamford, Conn.
Can. Rep., Ferro Enamels, Ont., Can.

Circle No. 34 on Reader Service Card

SEMICONDUCTOR EXECUTIVES $12,000 TO $50,000

PRODUCT MANAGER—to $50,000
Established manufacturer of silicon rectifiers needs man familiar with silicon controlled rectifiers who can take from original design through production. Compensation on a base salary and a percentage of profits plus other attractive options.

DIRECTOR OF RESEARCH & DEVELOPMENT—to $25,000 +
Semiconductor division of one of top 20 electronics firms needs Ph.D. with heavy experience in Semiconductor R&D.

MEASUREMENTS ENGINEER—to $16,000
Medium sized manufacturer needs man with electrical measurement experience and circuit design background who can advise R&D department on new techniques.

QUALITY CONTROL ENGINEER—to $15,000
Major manufacturer needs man with 3-5 years experience in quality control or reliability on semiconductor devices.

ASSISTANT DIVISION MANAGER—$30,000
Major West Coast manufacturer needs man with heavy manufacturing experience in the semiconductor industry.

NATIONAL SALES MANAGER—$20,000 +
Manufacturer of silicon and germanium transistors and diodes needs man to head up national sales force. Should have 10 years electronic components sales, of which 3 to 5 years is in sales management on semiconductor devices.

PROCESS ENGINEERING MANAGER—to $16,000
Man with heavy experience in diffusion and processing on silicon transistors and diodes. Should also have knowledge of crystal growing operation.

APPLICATIONS ENGINEER—to $12,000
Young E.E. with one or more years experience on transistorized circuit design. Must have pleasing personality and the ability to express himself well. Will lead into sales.

SCORES MORE
All expenses paid by employers. Completely confidential—no referrals wtihout your permission.

If you are interested in knowing more about these and many other Semiconductor Executive positions available through our services, but don't have a prepared resume, simply jot your home address and phone number on the back of your business card and mail it to:

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ELECTRONICS PERSONNEL CONSULTANTS
332 So. Michigan Ave., Chicago 4, Ill.—WEbster 9-3833
SERVING THE ELECTRONICS INDUSTRY EXCLUSIVELY—WITH INTEGRITY

Circle No. 35 on Reader Service Card

MINIATURE WELDERS

SPOTWELDER for VERY SMALL WORK
Model WHD 5A

- Pressure from 1 ounce or less, to 3 lbs. Calibrated scales.
- Low inertia produces fast forging action. Moving mass only 20 grams. Ball bearings.
- Inclined for better visibility.

STORED ENERGY POWER SUPPLIES – SMALL AC SYNCHRONOUS AND NON-SYNCHRONOUS TIMERS. TAPWELDERS FOR POTENTIOMETERS. PORTABLE THERMOCOUPLE WELDERS AND TACKERS. AIR OPERATED BENCHWELDERS AND PRODUCTION WELDING MACHINES.

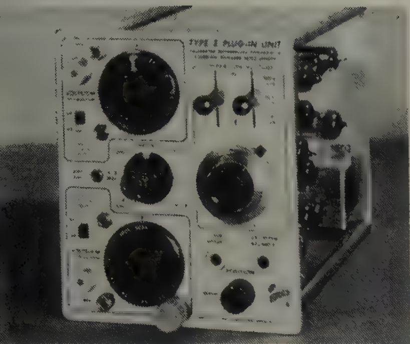
Write for data sheet and submit parts for sample welds.

EWALD INSTRUMENTS Route 7S, KENT, Conn.

Circle No. 36 on Reader Service Card

lew Products
(from page 55)

'lug-In Unit



A differential amplifier with large dy-
namic range, the new Type Z fits all Tektronix oscilloscopes that accept "let-
ter-series" plug-in units, enables meas-
urement of small segments of large wave-
forms at maximum vertical sensitivity, permits vertical expansion of a waveform for extremely detailed analysis and measurement. A 100-volt signal may be observed with 0.05 v/cm resolution, providing up to 500X vertical magnification. An accurate comparison voltage may be added differentially to the input waveform to place any amplitude segment, or 'window display" on screen.

Circle 131 on Reader Service Card

Solder Foil Alloys

Soft solder foil in wide range of alloys, melting points, and sizes is available from Accurate Specialties Co., Inc. These solder foil alloys include over 50 different alloys with melting points that vary from 100° C up to 400° C. The foil is available in widths up to 6.00" maximum and in thicknesses down to .0005" with tolerances held as close as plus or minus .0001".

Circle 130 on Reader Service Card

Test Set

A new 200 ampere dynamic test set, Model 164, to simultaneously evaluate the characteristics of four silicon rectifiers in a full wave circuit, is announced by Wallson Associates Inc. Peak reverse voltage is adjustable between 0-1500V; any combination of forward current and reverse voltage within these ranges may be obtained. Input is 208, 220 or 440 volts, 60 cps, 32 kva single phase.

Circle 117 on Reader Service Card

Dry Box Gloves

Butyl dry box gloves that are less permeable to gases and moisture are available from CAEMCO. In addition to their extremely low permeability, the gloves have outstanding resistance to concentrated acids, solvents, ketones etc., have excellent sensitivity, and are made of one piece, seamless construction.

Circle 115 on Reader Service Card

Transistor Test Socket

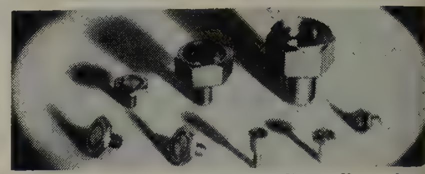
New socket for the production testing of 3 or 4 lead transistors is available from Jettron Products Inc. Socket occupies a volume of only 11/16" square x 1-7/16" long. Designed for 1/8" panel mounting in keyed hole and retained by a snap ring, sockets may be mounted on .812" centers. Double fingered spring contacts grip leads close to base of transistor with frictional force in excess of 50 grams on .017" diameter lead wires.

Circle 119 on Reader Service Card

NEW SERVICE NOW AVAILABLE

SEMICONDUCTOR PRODUCTS is making a new source of information available to all firms interested in being kept up to date on materials or equipment for producing semiconductor devices. If you wish to receive all new literature on silicon, gremanium, chemicals, machinery, or other such materials, circle #99 on the reader-service card. Your name will be placed on a special list which will be forwarded to all such suppliers. As these suppliers have news available in their field, you'll be notified by them immediately. This service is restricted to firms manufacturing semiconductor devices or firms contemplating entering into production within 120 days.

Semiconductor Bases



Standard Pressed Steel Co. offers improved copper semiconductor mounting bases which double as both electrically conducting mount and heat sink for transistors, rectifiers and other semiconductors. SPS cold forms the bases from either oxygen-free copper or a zirconium-copper alloy. The former material has high thermal and electrical conductivity; the zirconium copper provides a high strength unit that retains its strength at the elevated temperatures of brazing and welding that are employed for the final assembly of semiconductors.

Circle 133 on Reader Service Card

Transistor Heat Sinks

Heat Sinks for power transistors and diodes, especially designed for ease of mounting and stacking, are available from Invar Electronics Corp. Offering 25 square inches of surface area for each inch of length, they provide a large heat dissipating surface while maintaining a minimum overall size. The units are furnished with holes for mounting the power transistor, for mounting or "stacking" the heat sinks in a compact array, and for attaching a terminal or resistor board to the heat sink.

Circle 114 on Reader Service Card

Power Supply

Trygon Electronics, Inc., announces the expansion of the TRYLAB series with the availability of the T50-750 laboratory supply. Furnishing 0-50 VDC at 0-750 ma, this unit provides both constant voltage and constant current from a single supply. Both voltage and current regulation is better than 0.05%, while the voltage ripple is less than 0.5 millivolts and the current ripple less than 0.01%. Since the unit is adjustable down into the low millivolt region, it makes an ideal supply for tunnel diode applications.

Circle 129 on Reader Service Card

Environmental Vibration Machine

A new reaction-type environmental vibration machine, designed especially for testing small electronic components and assemblies in accordance with procedures described in MIL-T-19500B, has been introduced by the L. A. B. Corporation. The RV-15-25 has a maximum load capacity of 50 pounds, nominal load of 30 pounds and a table mounting surface of 15" x 15". Maximum excursion is .375" at nominal load and is adjustable from 0 to maximum at standstill. Frequency range is adjustable from 10 to 100 CPS.

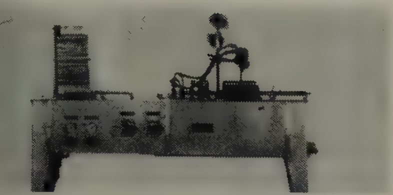
Circle 132 on Reader Service Card

Epoxy Hardener

Smooth-On Manufacturing Co. recently announced that their Sonite #41 Hardener is being used in a number of formulations for a new "Epoxy E-Pak System" patented by Epoxy Products Division, Joseph Waldman & Sons. The system is based on pre-measured, pre-weighed epoxy resin pellets, shells, and headers. Use of the proper hardener is a key factor in formulating an encapsulating system designed for high-volume, low-cost production of miniaturized semiconductor devices.

Circle 136 on Reader Service Card

pray Coater



A new and improved model remote pray coater on which the magazines are ortable, rather than a permanent and ntegral part as on previous models, has een announced by Conforming Matrix orporation. Model HD-3 will accurately pray coat axial lead components at the ate of 3,000 to 10,000 per hour, depending pon the part and the coating material. t will "lite-tite" seal silicon diodes and ther small electrical and electronic omponents.

Circle 120 on Reader Service Card

emiconductor Wafer Tweezers

Five new styles of semiconductor weezers for handling germanium and ilicon wafers have been designed by ngineers of R. N. Hunter Sales Company, nc. All feature smooth, large gripping urfaces with points that permit a posiive grip without breaking or scratching he polished surfaces of the thin, brittle vafers.

Circle 100 on Reader Service Card

ener Diode Series

Dickson Electronics Corporation introuces a new 10 Watt Zener Diode Series overing the voltage range of 6.8 to 200 olts. All units contain single *p-n* juncions formed by the carefully controlled liffusion at 1300° C of phosphorus into oron doped silicon.

Circle 111 on Reader Service Card

ilaments And Boats

A new complete line of tungsten, tanalum and molybdenum filaments and oats is available in a variety of sizes and hapes from Allen-Jones, Inc. Manufacured for use in high vacuum as an evaporation source, they are processed to naintain a high standard of purity and ccuracy. Primary uses include: elecronic component processing, coating of ptics, plastics and toy decorative coatng, precision instrumentation manufacuring, and vacuum metalizing in basic esearch laboratories.

Circle 113 on Reader Service Card

High Vacuum Oven

A new line of "cold wall" (water ooled shell) high vacuum bake ovens apable of operating continuously at any emperatures within the ranges of -500°C and 0-800°C, has been developed y the Industrial Division of Tri Metal Vorks. Temperature uniformity within he work zone is held to within ±3°C. The internal construction is such that suspended muffle is heated by radiant eaters and reflective shielding.

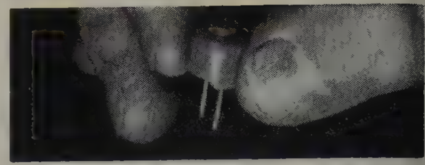
Circle 121 on Reader Service Card

esistivity Measurement Probe

Device Development recently announced the availability of their Microrobe, a highly accurate constant tension our point probe designed for resistivity neasurements on Semiconductor slices. Probe spacing is adjustable within a .040" range and is factory pre-set to pecified spacing plus or minus .0002". Probe tips are rhodium plated hard hrome steel. Tungsten probes optional.

Circle 109 on Reader Service Card

Infrared Detector



A new general-purpose lead sulfide detector is available from Tupper Trent Co., Inc. Designed expressly for industrial applications, this type FR-E47 cell may be used for scanning, counting, sorting, machine-operator safeguards, liquid and bin control, signaling, switching, and flame monitoring. This very stable photoconductor has a nominal $D^*_{(500,750,1)}$ of 8 x 10^8; a mean time constant of 375 microseconds; and a dark resistance range from kilohms to 1.5 megohms.

Circle 110 on Reader Service Card

Sleeve-Glove Combination

Wilson Rubber Co. has introduced its new Wil-Gard Interchangeable "Berkeley Box" dry box sleeve and glove combination. Sleeves are equipped with special detachable collars to which a wide selection of industrial gloves can be attached. This new design makes it possible to discard worn-out or damaged gloves without discarding the sleeves.

Circle 118 on Reader Service Card

Radiant Ovens

Sola-Jet Radiant Ovens from Temperature Engineering Corporation are a new concept in absolute constant-controlled temperature. They solve the problem of exacting temperature tolerances directly onto the work load with heaters placed on all six sides of the chamber. Specially designed "jack-in" heated aluminum shelves for applying direct heat to the work load are optional. Modifications will be engineered by Tempcor to meet specific needs.

Circle 123 on Reader Service Card

Gaseous Diffusion Boats

Duramic Products, Inc., offers gaseous diffusion boats in a new high-temperature high-heat shock resistant ceramic, for use in doping of silicon and germanium crystals for diffused base diodes, rectifiers and transistors. This HT-2 ceramic is able to withstand the rapid processing in semiconductor diffusion ovens at temperatures as high as 1300° C. The diffusion boats are custom fabricated to meet customer's requirements and are available in plate form ¼" thick x 5" max length x 3" max width.

Circle 128 on Reader Service Card

Portable Diode Tester

A completely portable diode tester, Model DTM-1001, has been announced by The A. W. Haydon Company. Measuring only 11½" x 10" x 10", the new twelve-pound unit was designed to test diode matrix boards used in conjunction with 16-switch or 28-switch electronic timers. The manual tester checks the presence and correct polarity of diodes in specified circuit positions on the diode matrix boards. It also tests the diode forward current at 1 volt and reverse leakage current at 25 volts. Operates in temperatures ranging from 40°F to 150°F.

Circle 124 on Reader Service Card

New Literature

A new 4-page brochure #E-1160, presenting production equipment for the electrical and electronics industries, is available from Hull Corporation. The catalog covers modern production systems used by these industries for impregnating, potting, encapsulating, plastics molding, relay drying and filling systems, urethane foaming, vacuum drying, upgrading of oils and waxes, and vacuum melting and heat treating.

Circle 140 on Reader Service Card

A new eight-page bulletin, describing and illustrating vacuum-type furnaces, has been published by Lindberg Engineering Company. Pictures and drawings in this bulletin show hot-wall vertical retort vacuum furnaces, horizontal retort vacuum furnaces, vacuum bell-type furnaces, cold-wall vacuum furnaces and a vacuum-atmosphere retort tube for research and pilot-plant use.

Circle 141 on Reader Service Card

Wire for use in the many phases of the semiconductor industry is the subject matter of a new pamphlet issued by Secon Metals Corporation. This 4-page brochure outlines the important factors involved in maintaining the physical and electrical properties of the many metals and alloys used by the industry. Discussed at length are the various purities and properties of gold and doped gold alloys as well as aluminum and doped aluminum wire. Tin, Indium and Lead Coated wire for semiconductor applications are likewise discussed in detail.

Circle 142 on Reader Service Card

A four page folder on "Replacement Gaskets and Parts for CBR Laboratories" has been released by the Kewaunee Scientific Equipment Division of Kewaunee Manufacturing Company. The folder illustrates and provides catalog numbers for all gaskets used to seal the various removable panels of the CBR Glove Boxes. In addition to the replacement gaskets, other expendable parts are illustrated and described. A price sheet is available with the folder.

Circle 143 on Reader Service Card

Tempcor Product Catalog, from Temperature Engineering Corporation, describes "VacU-Therm" vacuum ovens, diffused "Aer-Heet" chambers, "Sola-Jet" radiant ovens, dri-box vacuum bake systems, modular controlled atmosphere enclosures, and vacuum equipment. The 30-page catalog contains illustrations, descriptive drawings and technical specifications.

Circle 144 on Reader Service Card

A 32-page booklet gives a detailed presentation of all 16 presently-available Tektronix "A-to-Z" plug-in units. The booklet includes complete specifications and performance characteristics—with waveform patterns and other illustrative material for various measurement applications.

Circle 146 on Reader Service Card

(Continued on page 68)

Market News *(from page 59)*

The Sprague Electric Co. has acquired Vec Trol Engineering, Inc. of Stamford, Conn., manufacturer of silicon-controlled rectifier gate controls and thyratron grid controls for industrial electrical apparatus.

Negotiations have been started for the merger of Steiner-Ives, Inc. of Union, N. J. with Temperature Engineering Corporation of Riverton, N. J., designers and manufacturers of temperature and controlled atmosphere equipment for research, industry, communications and transportation. Steiner-Ives, Inc. manufactures ovens and furnaces and conveyor ovens and furnaces for industry.

Avnet Electronics Corporation announced the results of operations for the first quarter of the current fiscal year (July 1, 1960 through September 30, 1960). Net sales totalled $2,517,900 compared to net sales of $2,132,091 for the comparable quarter of the previous year. Net income totalled $275,947, or 18 cents per share on 1,573,222 shares outstanding. In the 1959 comparable quarter net income totalled $255,713 or 16 cents per share on shares presently outstanding.

The American Stock Exchange admitted to trading the stock of Arco Electronics, Inc., of New York. The firm manufactures and distributes silicon rectifiers, rectifiers, electric plugs and networks and has four subsidiaries—in Texas, California, Florida and New York. Arco plans a major expansion move to the Lake Success Business and Professional Park, Lake Success, N.Y., where it will have nearly twice its present floor space.

Expansions

Sylvania has started construction on their new applied research laboratory and new headquarters building in Waltham, Mass. The two new buildings, totaling about 107,000 square feet are being erected on a 55 acre site adjacent to their present facilities. Plans call for completion by Aug. 1.

The firm has also announced plans for a 17,000-square-foot addition to its semiconductor plant at Hillsboro, N. H. to accommodate advanced manufacturing and testing equipment to meet the growing demand for crystal diodes and transistors. Construction of the addition, scheduled to begin in April, will bring the total plant area to 53,000 square feet.

Imperial Chemical Industries Ltd. London, England has recently expanded its silicon plant and increased its production up to 10,000 pounds a year.

General Electric has formed a Signal Diode Project within its Semiconductor Products Department to concentrate attention on its fast-moving tunnel diode business. This move has been designed to separate tunnel diodes and other two-lead signal semiconductors from the transistor business.

Hoffman Electronics Corp. has recently dedicated its new Science Center, at Santa Barbara, Calif.

Columbus Electronics Corporation, manufacturers of double-diffused silicon rectifiers, has moved into its newly equipped 30,000 square feet production facility at 1000 Saw Mill River Road, Yonkers, New York, and is now in full production.

Delta Semiconductors, Inc., announced the opening of their new plant in Newport Beach, Calif. Delta makes a complete line of glass silicon computer switching and all purpose diodes.

New Firm

PRL Electronics Inc. Rahway, N. J. has recently been established. The firm has begun limited production of a semiconductor testing device and soon expects to start manufacturing a line of transistorized power supplies.

Contracts

A contract award of $2.3 million to Westinghouse Electric Corporation for continuing development of molecular electronics systems was announced jointly by the company and the U. S. Air Force. The air arm division of Westinghouse at Baltimore will manage the program, with the company's semiconductor department at Youngwood, Pa., and its central research laboratory at Churchill Borough, Pa., joining in the advanced molecular research and development begun slightly over two years ago.

New Literature

(from page 65)

A new two-color sheet illustrating and describing the Ultra-Cleen '320' Series of ultrasonic cleaners is available from L & R Manufacturing Company. The sheet contains illustrations and cutaway diagrams of the '320' (with one 1¼ quart transducerized tank and one 1¼ quart rinse tank), the '320D' (with two 1¼ quart transducerized tanks with selector switch) and the '320L' (with one 3⅜ quart transducerized tank). Complete specifications on each model are also included.

Circle 145 on Reader Service Card

Charleston Rubber Company has issued an all new 24 page standard size, illustrated Industrial Protective Equipment Catalog. The new Charco Catalog describes and illustrates all of the protective products manufactured for industry by the company. Particular emphasis is placed on the company's "Neo-Sol" and "Sensi-Touch" all milled Neoprene rubber and "Hy-Sol" Buna N, synthetic rubber protective gloves. The catalog contains a valuable chemical reference chart and a chart which helps select the proper glove, length, thickness, finish and size.

Circle 147 on Reader Service Card

Electronic Research Associates, Inc. announces the availability of their new 8 page, 2 color Condensed Transistor Power Supply Catalog. This catalog provides a full listing of the Company's line of solid state power supplies, including miniaturized power packs, power supplies for transistor application, solid state inverters, converters, frequency changers, high voltage solid state power packs, constant current generators, and related types. In addition to the listed model numbers, specifications and prices, full electrical and mechanical details are provided.

Circle 148 on Reader Service Card

A copy of the September-October issue of the Hoffman SPAN (Semiconductor Product Application News) is available to engineers. Illustrated articles on "Voltage Regulator Diode Surge Ratings" and "The Silicon Uni-Tunnel Diode" are featured as is a story on "Solar Cells for Voice Transmission."

Circle 150 on Reader Service Card

Technical Bulletin Z-108 describing gold alloy preforms for use in semiconductor processing is now available from Accurate Specialties Co. Semiconductor engineers are offered information on the use of gold alloy preforms for two applications: As a joining material to produce an ohmic junction; When doped with *N* or *P* type elements, as an alloy junction material. The bulletin lists melting point range of the gold alloys, along with typical alloys for various applications.

Circle 151 on Reader Service Card

General Electric announces publication of the fifth edition of the Transistor Manual. The new edition contains four new chapters and is expanded by 115 pages over the previous edition to 339 pages. New chapters include Tunnel Diode Theory and Switching Circuits, Tunnel Diode Amplifiers, Feedback and Servo Amplifiers and Test Circuits. The chapters on Silicon Controlled Rectifiers, Power Supplies, Transistor Specifications and Rectifier Specifications are expanded and revised. Available at a nominal charge.

Circle 153 on Reader Service Card

Personnel Notes

Irwin Stelzer has been named Sales [M]anager for Alloys Unlimited Chemicals, [In]c. of Long Island City where he will [su]pervise sales and market research. Pre[v]iously, Mr. Stelzer was a Sales Executive [fo]r United Mineral & Chemical Corp. [S]ince the inception of the semiconductor [in]dustry, he has specialized in marketing [so]lid state materials.

The appointment of Francis H. Ander[s]on as superintendent of the El Segundo [C]alifornia, Works of Allied Chemical's [G]eneral Chemical Division was an[n]ounced by J. Steele Brown, vice presi[d]ent. With the division 19 years, Mr. An[d]erson was superintendent of its plant [i]n Elizabeth, New Jersey for the past [th]ree.

General Instrument Corporation an[n]ounced the appointment of Ted Cutler [a]s Distributor Sales Manager of its [w]holly-owned subsidiary, Radio Receptor [C]ompany. Mr. Cutler will supervise the [s]ale of all selenium rectifiers and radio [a]nd television replacement silicon recti[f]iers to independent distributors through[o]ut the United States and Canada.

Sylvania has announced that Dr. Sey[m]our Stein and Dr. James E. Storer of [t]he company's Applied Research Lab[o]ratory have been promoted to senior [s]cientists, the first to achieve that position [w]ithin GT&E. Dr. Leonard S. Sheingold, [D]irector of the Applied Research Labora[t]ory, said the new positions are in recog[n]ition of "outstanding scientific contribu[t]ions."

Ernest L. Ward has been elected presi[d]ent of Sprague Electric Company, Rob[e]rt C. Sprague, chairman of the board [a]nd chief executive officer of the com[p]any, announced recently. Mr. Ward re[p]laces the late Julian K. Sprague.

Appointment of Dr. Ralph P. Ruth as a [s]enior scientist at the Hoffman Science [C]enter, Santa Barbara, Calif., was an[n]ounced by Dr. Lloyd T. DeVore, Center [d]irector and vice president of Hoffman [E]lectronics Corporation. Dr. Ruth's re[s]earch work at the Science Center will be [p]rimarily in the field of thin films for [s]olar cell applications.

Hevi-Duty Electric Company, a Division of Basic Products Corporation recently named Robert M. Palmer as overall Field Sales Manager for the firm's industrial and laboratory furnace and oven divisions.

Rainer Zuleeg has been appointed senior staff physicist of Hughes Aircraft Company's semiconductor division in Newport Beach, Calif., it was announced by Dr. Earl L. Steele, manager of the division's research and development laboratory. In his new position, which is equivalent to a department head within the division, Mr. Zuleeg will conduct advanced research on the theory of parametric amplification and other studies on semiconductor properties.

Donald Christiansen has been named to the new post of manager of publications for the CBS Electronics division of Columbia Broadcasting System, Inc., in an announcement by R. A. Juusola, manager of marketing services. Mr. Christiansen was previously manager of information services, a position to which he was appointed in January, 1958. He joined CBS Electronics in 1950.

Dr. Erwin M. Koeritz was recently appointed Manager of Manufacturing, Metallurgical Products Department, General Electric Company, Detroit. The appointment was announced by Henry F. DeLong, Department General Manager. Since 1956 Dr. Koeritz has been Manager of Manufacturing Engineering in the firm's Silicone Products Department, Waterford, New York.

Jack Magarian recently joined the Fairchild Semiconductor Corporation as production control manager. He was formerly employed by General Electric Capacitor Department in Fort Edwards, New York, where he was supervisor for eight years in the Small Industrial Capacitor Department.

Erik Jonsson of Dallas, Texas, chairman of the board of Texas Instruments Incorporated, has been named chairman of the Southern Region, Science Center Fund of Rensselaer Polytechnic Institute.

INDEX TO ADVERTISERS

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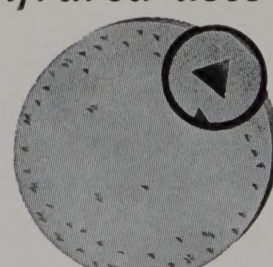

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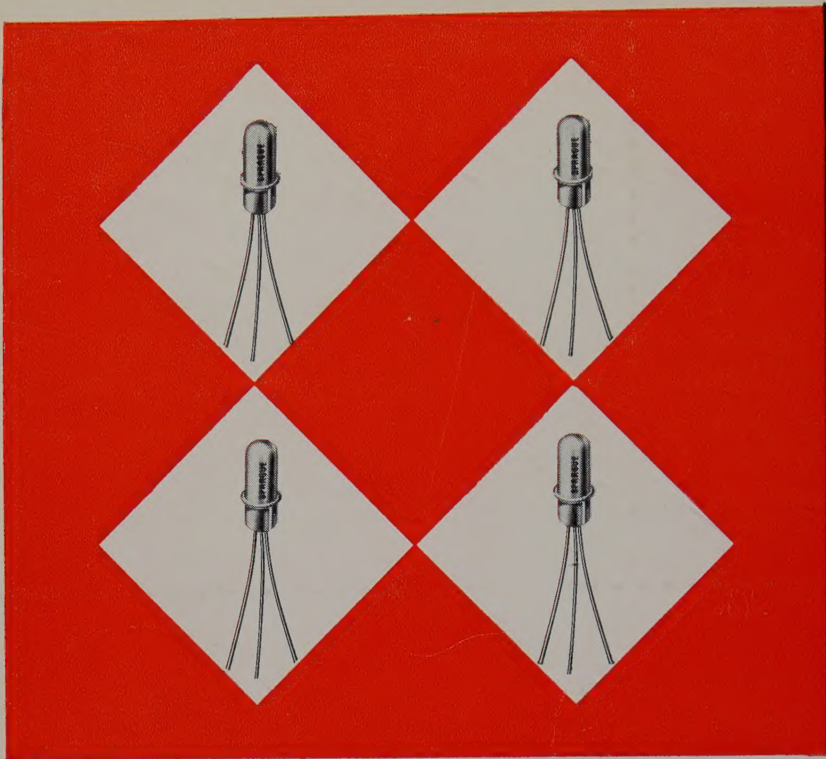

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